OPERATING SYSTEMS

CPU Scheduling

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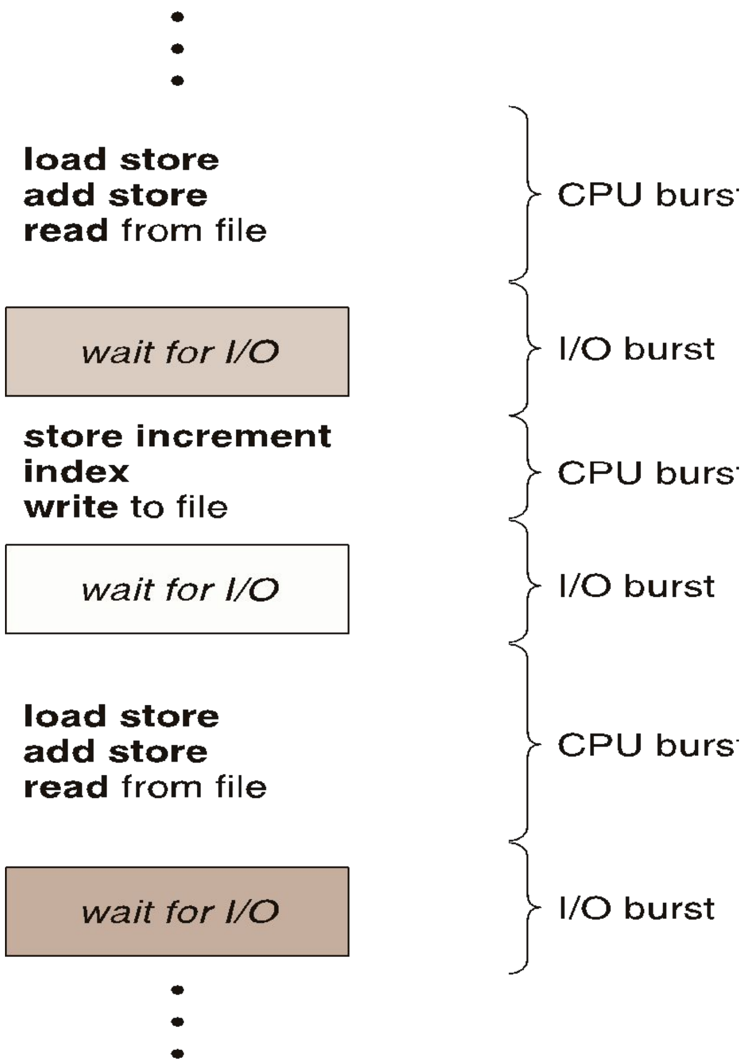
- In a system with a single CPU core, only one process can run at a time. Others must wait until the CPU is free and can be rescheduled.
- The objective of multiprogramming is to have some process running at all times, to maximize CPU utilization.
- Several processes are kept in memory at one time.
- When one process has to wait, the operating system takes the CPU away from that process and gives the CPU to another process. This pattern continues.
- Every time one process has to wait, another process can take over use of the CPU. On a multicore system, this concept of keeping the CPU busy is extended to all processing cores on the system.

Basic Concepts (Contd)

- The idea is relatively simple. A process is executed until it must wait, typically for the completion of some I/O request.
- In a simple computer system, the CPU then just sits idle. All this waiting time is wasted; no useful work is accomplished. With multiprogramming, we try to use this time productively.
- Scheduling of this kind is a fundamental operating-system function.
- Almost all computer resources are scheduled before use. The CPU is, of course, one of the primary computer resources. Thus, its scheduling is central to operating-system design.

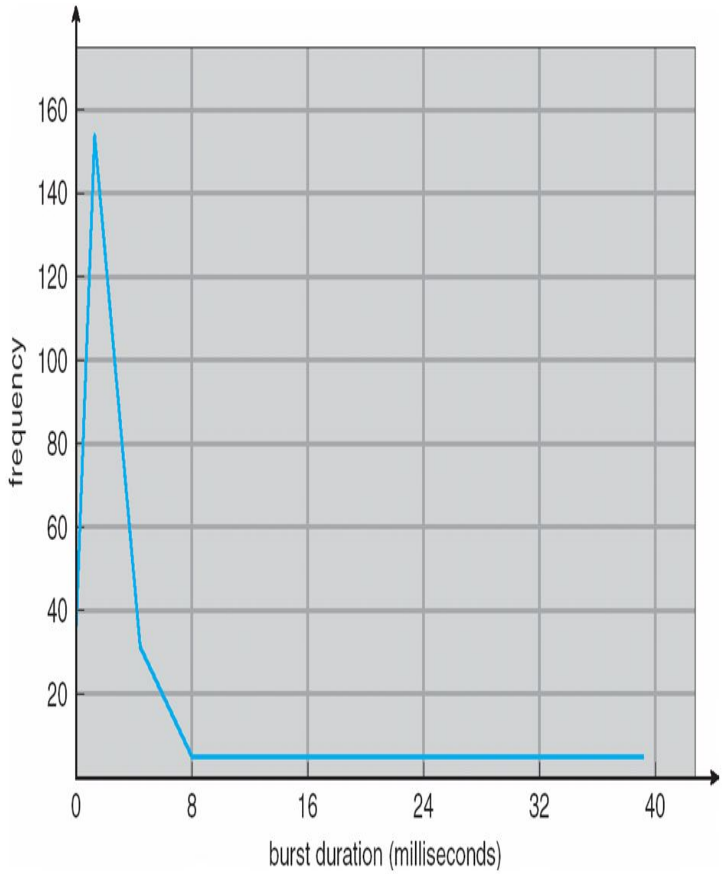
Alternating Sequence of CPU and I/O bursts

- Maximum CPU utilization obtained with multiprogramming
- CPU–I/O Burst Cycle – Process execution consists of a **cycle** of CPU execution and I/O wait
- **CPU burst** followed by **I/O burst**
- CPU burst distribution is of main concern



Histogram of CPU-burst Times

- The durations of CPU bursts have been measured extensively. Although they vary greatly from process to process and from computer to computer, they tend to have a frequency curve similar to that shown in the Figure.
- An I/O-bound program typically has many short CPU bursts. A CPU-bound program might have a few long CPU bursts. This distribution can be important when implementing a CPU-scheduling algorithm.



CPU Scheduler

- **Short-term scheduler** selects from among the processes in ready queue, and allocates the CPU to one of them
  - Queue may be ordered in various ways
- CPU scheduling decisions may take place when a process:
  1. Switches from running to waiting state
  2. Switches from running to ready state
  3. Switches from waiting to ready
  4. Terminates
- Scheduling under 1 and 4 is **nonpreemptive**
- All other scheduling is **preemptive**
  - Consider access to shared data
  - Consider preemption while in kernel mode
  - Consider interrupts occurring during crucial OS activities

Preemptive vs Non-Preemptive Scheduling

- Under non-preemptive scheduling, once the CPU has been allocated to a process, the process keeps the CPU until it releases it either by terminating or by switching to the waiting state.
- Virtually all modern operating systems including Windows, macOS, Linux, and UNIX use preemptive scheduling algorithms.
- Unfortunately, preemptive scheduling can result in race conditions when data are shared among several processes. Ex: While one process is updating the shared data, it is preempted so that the second process can run. The second process then tries to read the data, which are in an inconsistent state.
- A pre-emptive kernel requires mechanisms such as mutex locks to prevent race conditions when accessing shared kernel data structures. Most modern operating systems are now fully preemptive when running in kernel mode.

Dispatcher

- Dispatcher module gives control of the CPU to the process selected by the short-term scheduler; this involves:
    - switching context
    - switching to user mode
    - jumping to the proper location in the user program to restart that program
- **Dispatch latency** – time it takes for the dispatcher to stop one process and start another running

Scheduling Criteria

- **CPU utilization** – keep the CPU as busy as possible
- **Throughput** – # of processes that complete their execution per time unit
- **Turnaround time** – amount of time to execute a particular process (performance metric)
- **Waiting time** – amount of time a process has been waiting in the ready queue
- **Response time** – amount of time it takes from when a request was submitted until the first response is produced, not output (for time-sharing environment)

Scheduling Algorithm Optimization Criteria

- Maximize CPU utilization
- Maximize throughput
- Minimize turnaround time
- Minimize waiting time
- Minimize response time

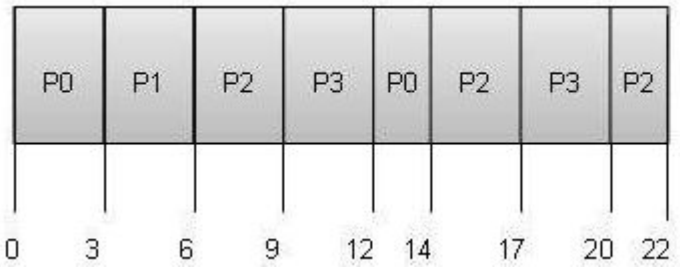
Sample Schemas and Tools for solving Scheduling Problems

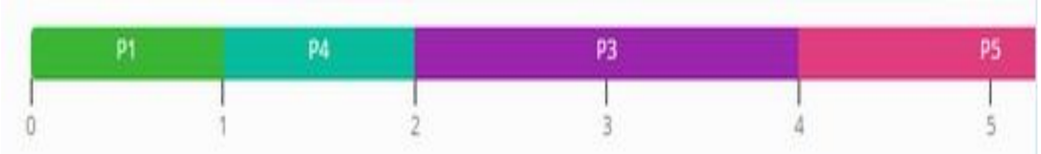
Process	Arrival Time	Execute Time	Service Time

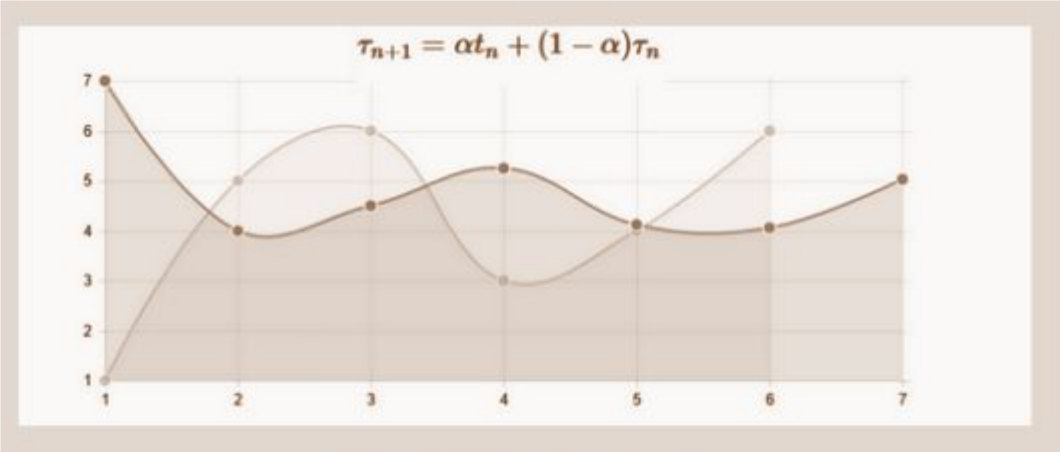
Process	Execution time	Arrival time

Process	Arrival Time	Execution Time	Priority	Service Time

GANTT Chart







CPU Burst Predictor

Sample Schemas and Tools for solving Scheduling Problems

Arrival Time: Time at which the process arrives in the ready queue.

Completion Time: Time at which process completes its execution.

Burst Time: Time required by a process for CPU execution.

Turn Around Time: Time Difference between completion time and arrival time.

Turn Around Time = Completion Time – Arrival Time

Waiting Time(W.T): Time Difference between turn around time and burst time.

Waiting Time = Turnaround Time – Burst Time

THANK YOU

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