



Operating Systems

Introduction to CPU Scheduling

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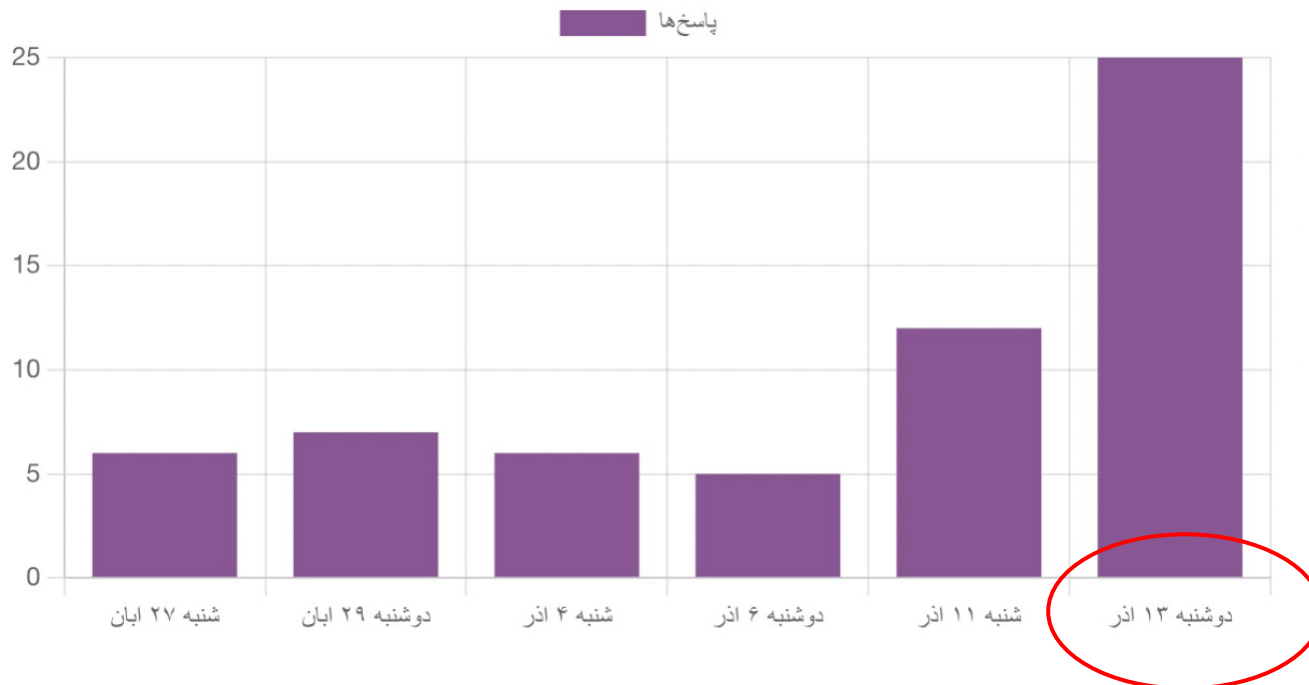
Fall 2023

Course Logistics

Midterm exam date

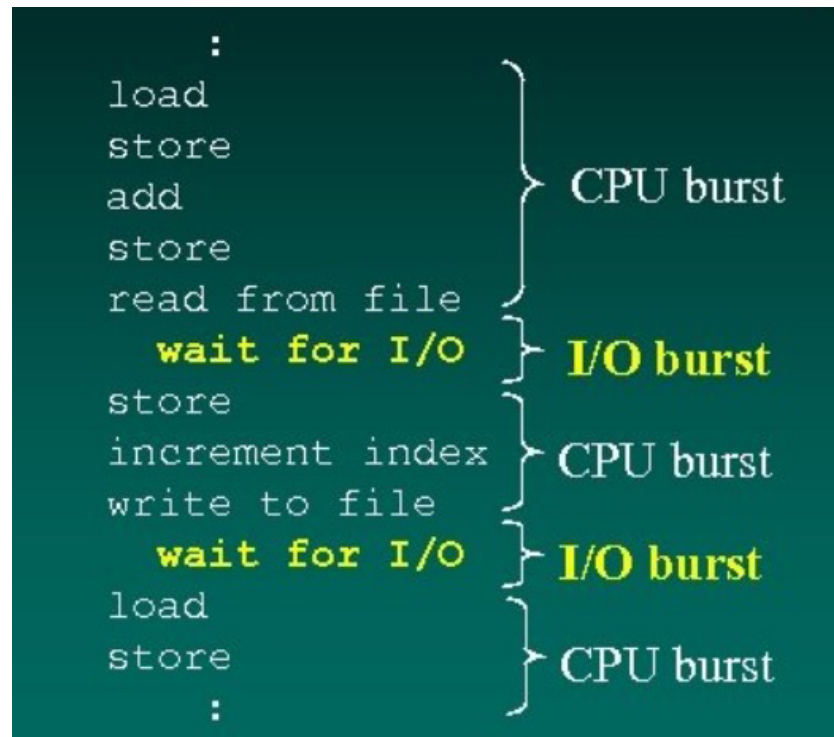
پاسخ‌ها

| | |
|------------|----------------|
| (15.4%) 6 | شنبه ۲۷ آبان |
| (17.9%) 7 | دوشنبه ۲۹ آبان |
| (15.4%) 6 | شنبه ۴ آذر |
| (12.8%) 5 | دوشنبه ۶ آذر |
| (30.8%) 12 | شنبه ۱۱ آذر |
| (64.1%) 25 | دوشنبه ۱۳ آذر |



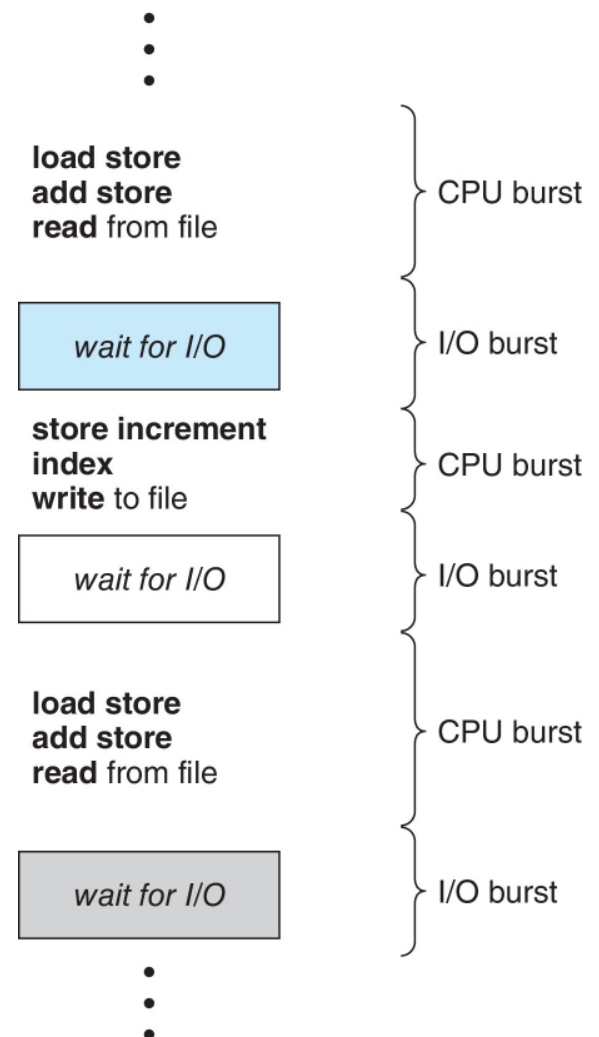
Basic Concepts

- Maximum CPU utilization obtained with multiprogramming
- CPU-I/O Burst Cycle
 - Process execution consists of a **cycle** of CPU execution and I/O wait

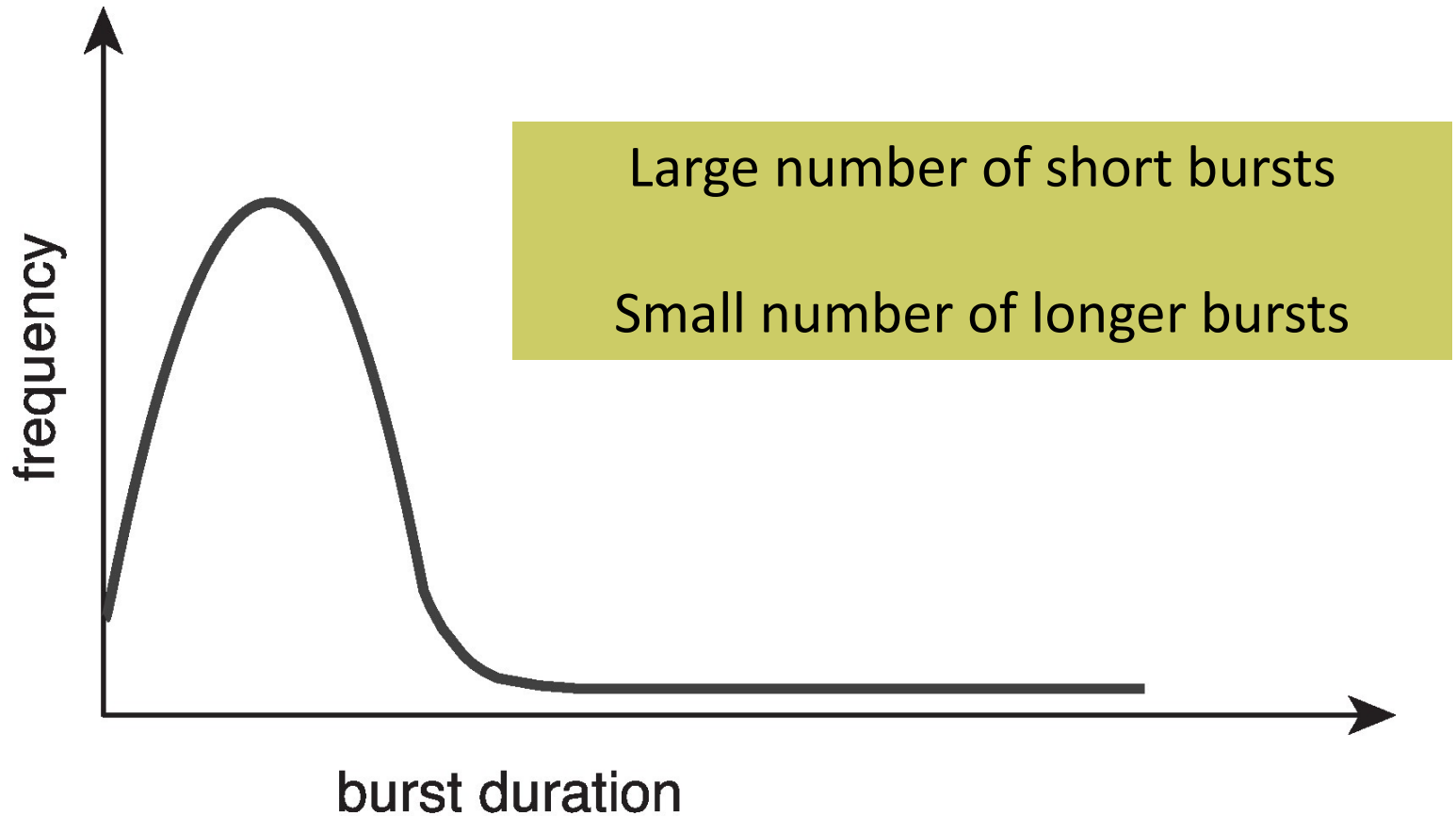


Basic Concepts

- **CPU burst** followed by **I/O burst**
- CPU burst distribution is of main concern

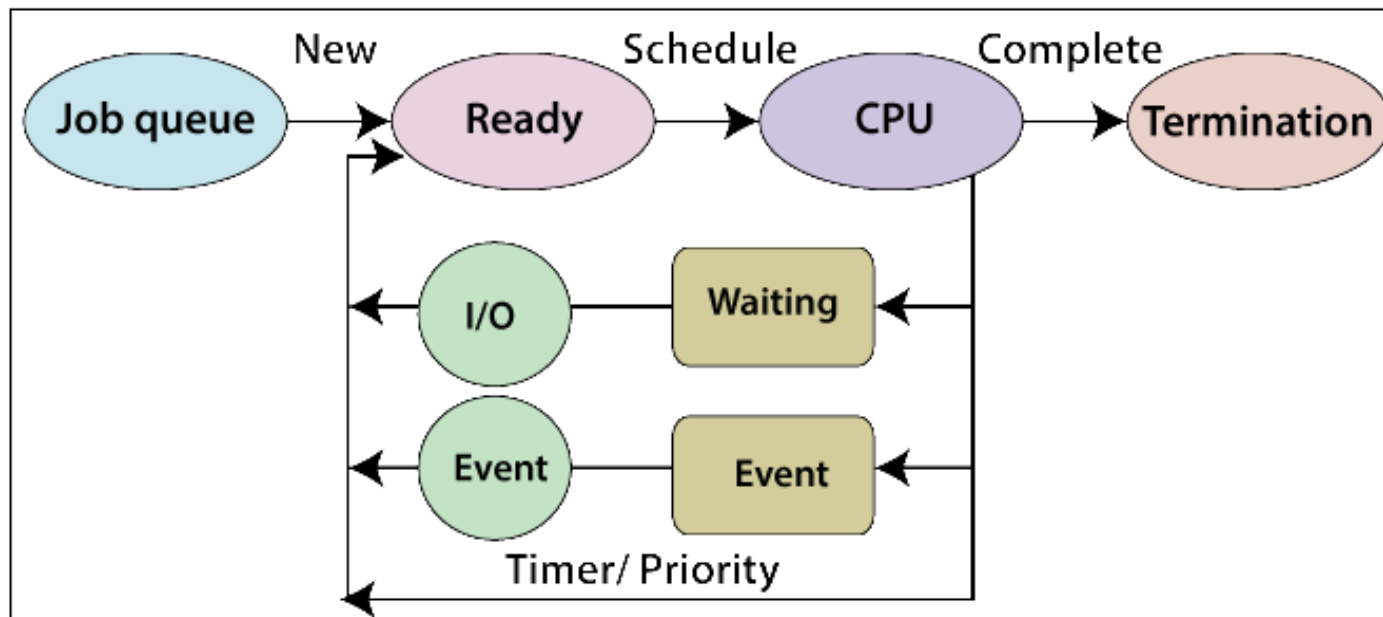


Histogram of CPU-burst Times



CPU Scheduler

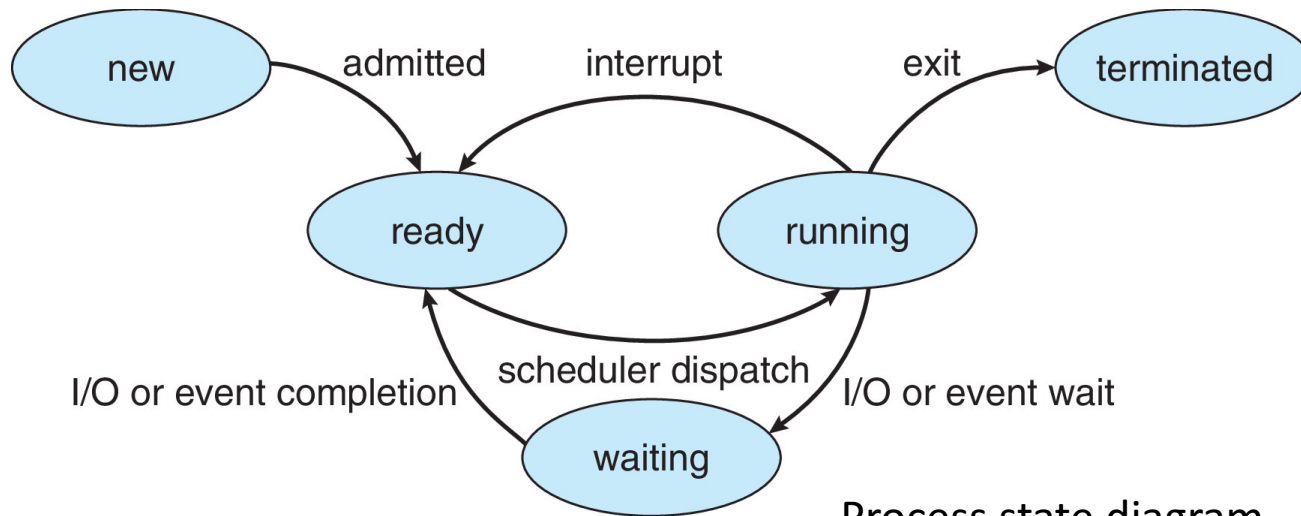
- The **CPU scheduler** selects from among the processes in ready queue and allocates a CPU core to one of them.
 - Queue may be ordered in various ways.



<https://www.tutorialandexample.com/process-schedulers-and-process-queue/>

CPU Scheduler (cont.)

- 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**



Process state diagram

CPU Scheduler (cont.)

- **Four possible scheduling situations**
 1. Switches from running to waiting state
 2. Switches from running to ready state
 3. Switches from waiting to ready
 4. Terminates

- For situations 1 and 4, there is **no choice in terms of scheduling**.
 - A new process must be selected for execution.
 - If at least one process exists in the ready queue

- For situations 2 and 3, however, there is a choice.



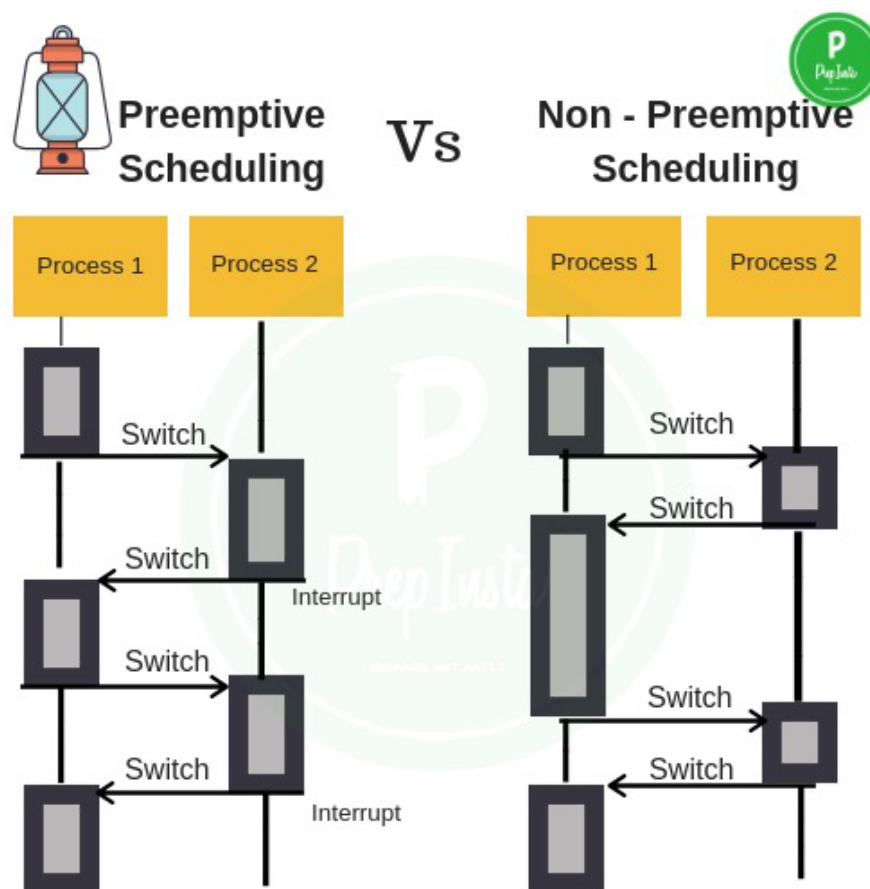
Preemptive and Nonpreemptive Scheduling

■ Non-preemptive (or cooperative)

- Circumstances 1 and 4

■ Preemptive

- Circumstances 2 and 3



Preemptive and Non-preemptive Scheduling (cont.)

■ 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 use preemptive scheduling algorithms.

- Including Windows, MacOS, Linux, and UNIX



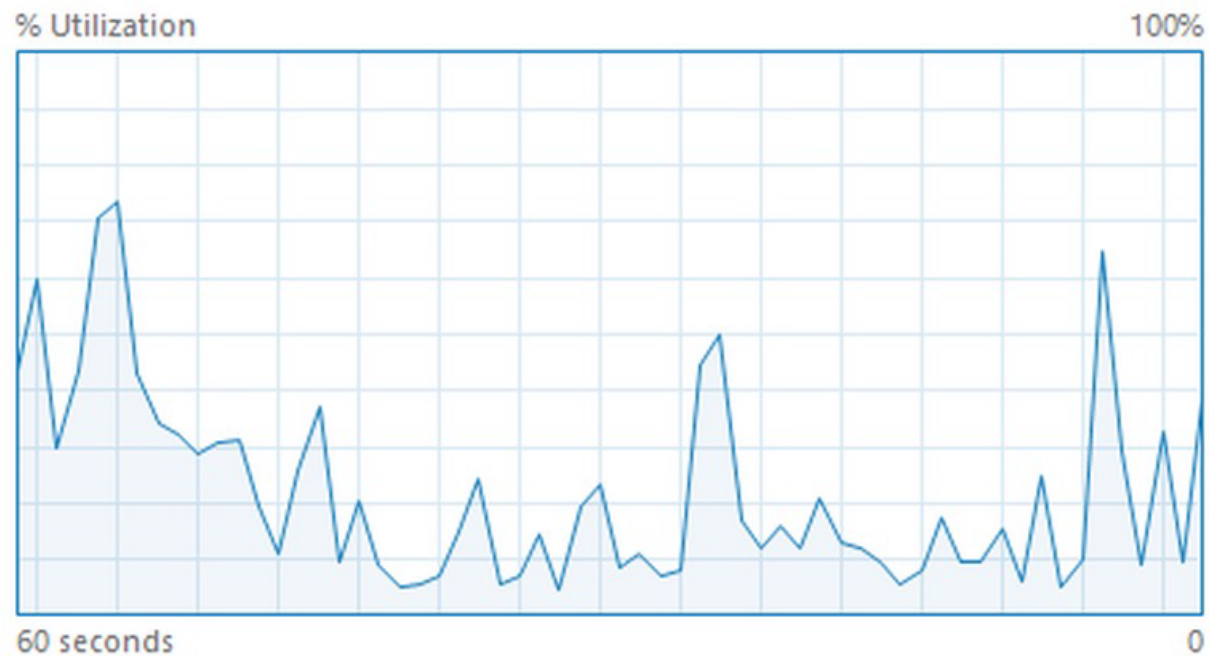
Scheduling Criteria

- CPU utilization
- Throughput
- Turnaround time
- Waiting time
- Response time



CPU Utilization

- Keep the CPU as busy as possible.



Throughput

- Number of processes that complete their execution per time unit.



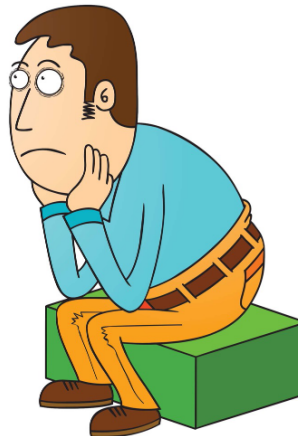
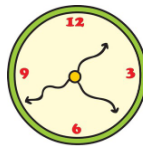
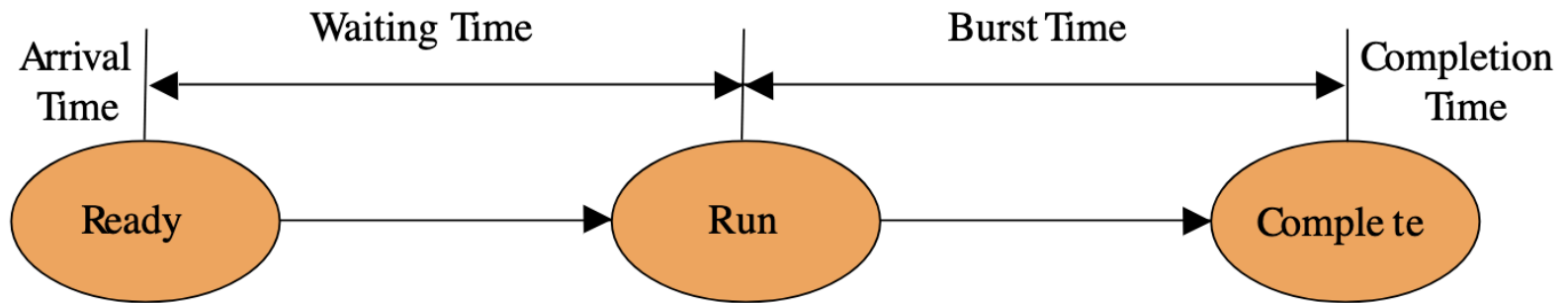
Turnaround Time

- Amount of time to execute a particular process.
- Sum of the periods spent waiting, in the ready queue, executing on the CPU, and doing I/O.



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.



Scheduling Algorithm Optimization Criteria

| Criteria | Min or Max? |
|-----------------|-------------|
| CPU utilization | |
| Throughput | |
| Turnaround time | |
| Waiting time | |
| Response time | |



Scheduling Algorithm Optimization Criteria

- Max CPU utilization
- Max throughput
- Min turnaround time
- Min waiting time
- Min response time

