[5] 1.5) In a multiprogramming and time-sharing environment, several users share the system simultaneously. This situation can result in various security problems.

a) What are two such problems?

1. One user can read the private data of another user - privacy.

2. One user can corrupt the private data of another user - integrity.

3. One user can prevent another user from getting anything done - denail of service.

b) Can we ensure the same degree of security in a time-shared machine as we have in a dedicated machine? Explain your answer.

There are two answers, either one correct.

Yes - if we can ensure that the operating system prevents any sharing of data between users, either for reading or writing, and fairly shares the computer, then we can achieve the same level of security.

No - we can never be sure that our software doesn't have bugs, so we can never be sure that we prevent all sharing of data and fairly allocate computer resources.

[5] 1.8: Under what circumstances would a user be better off using a time-sharing system, rather than a PC or single-user workstation.

A user is better off under three situations: when it is cheaper, faster, or easier. For example:

1. When the user is paying for management costs, and the costs are cheaper for a time-sharing system than for a single-user computer.

2. When running a simulation or calculationg that takes too long to run on a single PC or workstation.

3. When a user is travelling and doesn't have laptop to carry around, they can connect remotely to a time-shared system and do their work.

Difference between Arrival Time and Burst Time in CPU Scheduling

CPU scheduling algorithms require CPU time and IO time required for its execution. CPU time is time taken by CPU to carry out the process while I/O time illustrates the time required for I/O operation by the process.
The execution of multiple processes in an optimised way is based on different kinds of algorithms, like FCFS, Shortest Job First etc., which depend on the time frame values, like the Arrival Time, Burst Time, Waiting Time etc.

1. Arrival Time (AT) :

Arrival time is the point of time in milli seconds at which a process arrives at the ready queue to begin the execution. It is merely independent of the CPU or I/O time and just depicts the time frame at which the process becomes available to complete its specified job.The process is independent of which process is there in the Running state. Arrival Time can be calculated as the difference of the Completion Time and the Turn Around Time of the process.

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Arrival Time (A.T.)

= Completion Time (C.T.) - Turn Around Time (T.A.T)
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2. Burst Time (BT) :
Burst Time refers to the time required in milli seconds by a process for its execution. The Burst Time takes into consideration the CPU time of a process. The I/O time is not taken into consideration. It is called as the execution time or running time of the process. The process makes a transition from the Running state to the Completion State during this time frame. Burst time can be calculated as the difference of the Completion Time of the process and the Waiting Time, that is,

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Burst Time (B.T.)

= Completion Time (C.T.) - Waiting Time (W.T.)
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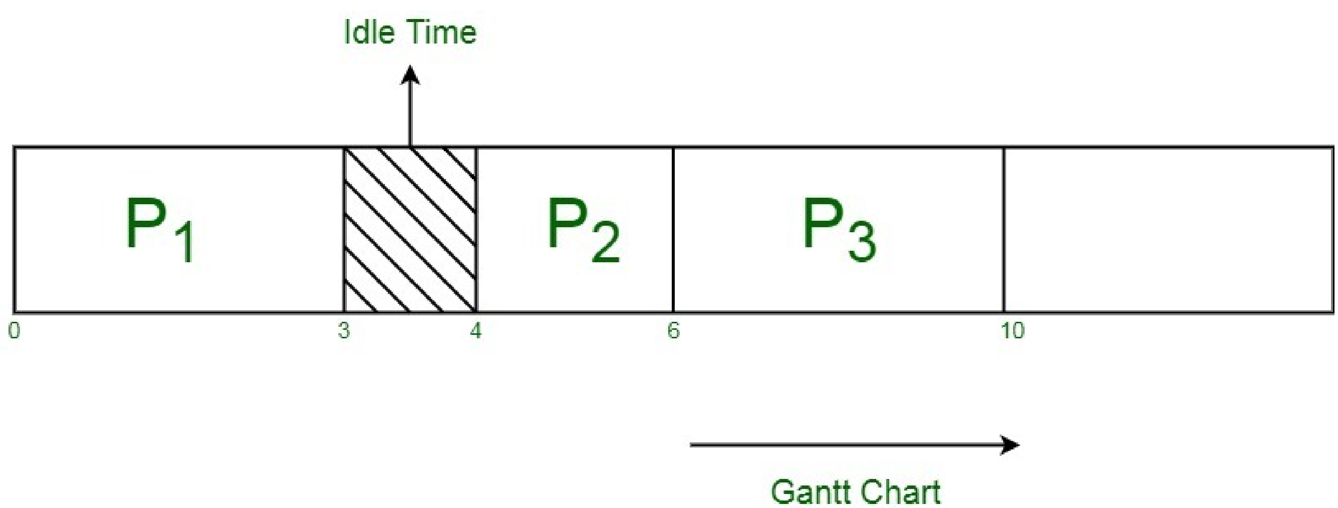
The following table illustrates the Arrival and Burst time of three processes P1, P2 and P3. A single CPU is allocated for the execution of these processes.

Processes	Arrival Time (in ms)	Burst Time (in ms)
P1	0	3
P2	4	2
P3	6	4

If we compute the Gantt chart, based on FCFS scheduling where the process that comes first in the ready queue is executed first. The processes arrival decides the order of execution of the process for time equal to its Burst time.



Since, the process P2 arrives at 4ms, and process P1 requires 3ms for its execution (=Burst Time), CPU waits for 1ms, that is the idle time for the CPU, where it doesn't perform any process execution. The last process to get executed is P3.

The following table illustrates the key differences in the Arrival and Burst Time respectively :

Arrival Time	Burst Time

Marks the entry point of the process in the queue.	Marks the exit point of the process in the queue.
Computed before the execution of process.	Computed after the execution of process.
Related to the Ready State of the CPU.	Related to the Running State of the CPU.

Burst time

Every process in a computer system requires some amount of time for its execution. This time is both the CPU time and the I/O time. The CPU time is the time taken by CPU to execute the process. While the I/O time is the time taken by the process to perform some I/O operation. In general, we ignore the I/O time and we consider only the CPU time for a process. So, **Burst time is the total time taken by the process for its execution on the CPU.**

Arrival time

Arrival time is the time when a process enters into the ready state and is ready for its execution.

Process	Arrival time	Burst time
P1	0 ms	8 ms
P2	1 ms	7 ms
P3	2 ms	10 ms

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Here in the above example, the arrival time of all the 3 processes are 0 ms, 1 ms, and 2 ms respectively.

Exit time

Exit time is the time when a process completes its execution and exit from the system.

Response time

Response time is the time spent when the process is in the ready state and gets the CPU for the first time. For example, here we are using the First Come First Serve CPU scheduling algorithm for the below 3 processes:

Process	Arrival time	Burst time
P1	0 ms	8 ms
P2	1 ms	7 ms
P3	2 ms	10 ms

Here, the response time of all the 3 processes are:

- **P1:** 0 ms
- **P2:** 7 ms because the process P2 have to wait for 8 ms during the execution of P1 and then after it will get the CPU for the first time. Also, the arrival time of P2 is 1 ms. So, the response time will be 8-1 = 7 ms.
- **P3:** 13 ms because the process P3 have to wait for the execution of P1 and P2 i.e. after 8+7 = 15 ms, the CPU will be allocated to the process P3 for the first time. Also, the arrival of P3 is 2 ms. So, the response time for P3 will be 15-2 = 13 ms.

Response time = Time at which the process gets the CPU for the first time - Arrival time

Waiting time

Waiting time is the total time spent by the process in the ready state waiting for CPU. For example, consider the arrival time of all the below 3 processes to be 0 ms, 0 ms, and 2 ms and we are using the First Come First Serve scheduling algorithm.

Process	Arrival time	Burst time
P1	0 ms	8 ms
P2	0 ms	7 ms
P3	2 ms	10 ms

Gantt Chart

P1	P2	P3
0 ms 8 ms	**8 ms 15 ms**	**15 ms 25 ms**

Then the waiting time for all the 3 processes will be:

- **P1:** 0 ms
- **P2:** 8 ms because P2 have to wait for the complete execution of P1 and arrival time of P2 is 0 ms.
- **P3:** 13 ms becuase P3 will be executed after P1 and P2 i.e. after 8+7 = 15 ms and the arrival time of P3 is 2 ms. So, the waiting time of P3 will be: 15-2 = 13 ms.

Waiting time = Turnaround time - Burst time

In the above example, the processes have to wait only once. But in many other scheduling algorithms, the CPU may be allocated to the process for some time and then the process will be moved to the waiting state and again after some time, the process will get the CPU and so on.

There is a difference between waiting time and response time. Response time is the time spent between the ready state and getting the CPU for the first time. But the waiting time is the total time taken by the process in the ready state. Let's take an example of a round-robin scheduling algorithm. The time quantum is 2 ms.

Process	Arrival time	Burst time
P1	0 ms	4 ms
P2	0 ms	6 ms

Time Quantum = 2ms

Gantt Chart

P1	P2	P1	P2	P2
0 2	2 4	4 6	6 8	8 10

In the above example, the response time of the process P2 is 2 ms because after 2 ms, the CPU is allocated to P2 and the waiting time of the process P2 is 4 ms i.e turnaround time - burst time (10 - 6 = 4 ms).

Turnaround time

Turnaround time is the total amount of time spent by the process from coming in the ready state for the first time to its completion.

Turnaround time = Burst time + Waiting time

or

Turnaround time = Exit time - Arrival time

For example, if we take the First Come First Serve scheduling algorithm, and the order of arrival of processes is P1, P2, P3 and each process is taking 2, 5, 10 seconds. Then the turnaround time of P1 is 2 seconds because when it comes at 0th second, then the CPU is allocated to it and so the waiting time of P1 is 0 sec and the turnaround time will be the Burst time only i.e. 2 seconds. The turnaround time of P2 is 7 seconds because the process P2 have to wait for 2 seconds for the execution of P1 and hence the waiting time of P2 will be 2 seconds. After 2 seconds, the CPU will be given to P2 and P2 will execute its task. So, the turnaround time will be 2+5 = 7 seconds. Similarly, the turnaround time for P3 will be 17 seconds because the waiting time of P3 is 2+5 = 7 seconds and the burst time of P3 is 10 seconds. So, turnaround time of P3 is 7+10 = 17 seconds.

Different CPU scheduling algorithms produce different turnaround time for the same set of processes. This is because the waiting time of processes differ when we change the CPU scheduling algorithm.

Throughput

Throughput is a way to find the efficiency of a CPU. It can be defined as the number of processes executed by the CPU in a given amount of time. For example, let's say, the process P1 takes 3 seconds for execution, P2 takes 5 seconds, and P3 takes 10 seconds. So, throughput, in this case, the throughput will be (3+5+10)/3 = 18/3 = 6 seconds.

Various Times related to the Process