

1. (10%) A multithreaded web server is usually considered as a better solution than a single-threaded web server. Are there any circumstances where a single-threaded server might be better? Please provide two cases.
2. (10%) A system has three processes and four identical resources. Each process needs a maximum of two resources. Describe a case that deadlock happens in the system.
3. (10%) Computing jobs are continuously submitted to a computer cluster consisting of tens of servers. The management component of the cluster puts the received jobs in the buffer and then chooses one job from the buffer for execution. Is starvation possible? Explain your answer.
4. (10%) Live migration of virtual machine (VM) refers to the process of moving a running virtual machine between different physical machines without disconnecting the client. Memory, storage, and network connectivity of the virtual machine are transferred from the original physical machine to the destination physical machine. The applications on the VM are still running during the migration time.

Please explain how and why the “dirty bitmaps” tracking technique can improve the efficiency of live migration.

5. (10%) In a batch computing system, on average 5 computing jobs arrive per minute, and normally 13 computing jobs in queue. What is the average waiting time in queue?
6. (30%) Suppose that the following processes arrive for execution at the times indicated. Each process will run the listed amount of time. You may make some reasonable assumptions and write them down explicitly, if they are necessary to answer the following questions.
 - (a) Please draw Gantt charts that illustrate the execution of these processes using the following scheduling algorithms: FCFS, non-preemptive SJF, and preemptive SJF.
 - (b) Which of the algorithms in (a) results in the minimum average turnaround time (over all processes)? Be sure to justify your answer.
 - (c) Which of the algorithms in (a) results in the minimum average waiting time (over all processes)? Be sure to justify your answer.

| Process | Arrival Time | Burst Time |
|---------|--------------|------------|
| P1 | 0 | 10 |
| P2 | 5 | 3 |
| P3 | 3 | 5 |
| P4 | 4 | 4 |

7. (20%) Are the following statements true or false? For each statement, you will get 4 points for correct answer, zero point for blank, or -2 point for incorrect answer.
- (a) When a process is created using the classical fork() system call, process ID is inherited by the child process
 - (b) The parent-child relationship is required for named pipes.
 - (c) FF:FF:FF:FF:FF:FF is a broadcast address in Ethernet networks.
 - (d) DHCP allows a host to dynamically obtain its IP address from network server when it joins the network
 - (e) Pretending that deadlocks never occur in the system is a method to deal with deadlocks