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資格考試科目：高等作業系統

Instructions: There are **five** questions which count 100 points in total. Each question may have several sub-questions. Please read the questions carefully before answering.

1. (16 pts) A virtual memory system can be structured on fixed-size pages and variable-size segments.
  - A. (4 pts) Compare the two approaches; describe one scenario the paging approach work better than the segment approach.
  - B. (4 pts) Following the previous question, describe one scenario the segment-based approach works better than the paging approach.
  - C. (8 pts) Describe two tradeoffs involved in having a design of smaller pages versus larger pages?
  
2. (12 pts) Two common approaches to structure an operating system kernel: Monolithic kernel vs. microkernel. A monolith approach puts all operating system into one executable while a microkernel approach puts only allows bare essential functions to run in privileged mode.
  - A. (6 pts) which approach provides better efficiency and why?
  - B. (6 pts) which approach provides better security for the kernel and why?
  
3. (18 pts) Shortest Job First (SJF) is an optimal scheduling algorithm in terms of minimized average waiting time.
  - A. (6 pts) Proof the optimality.
  - B. (6 pts) Describe the problem and solution when we implement SJF.
  - C. (6 pts) Since it is optimal, why we don't see SJF in contemporary OSes?
  
4. (16 pts) In a multi-processor/core systems, shared memory can reduce the inter-process/core communication overhead. To assure data consistence for shared memory, consistency models are used to describe what level of data consistency are provided in the system.
  - A. (8 pts) Strict consistency model requires that all the read operations must read the value the mostly recent written value. Please describe the challenges for implementing this model on loosely coupled distributed systems?
  - B. (8 pts) Sequential consistency model requires that all the processes on the system see the same order of memory access. Please describe the rationale for not preserving the memory access order in consistent with actual memory access order.
  
5. (20 pts) Please answer the following questions for process synchronization:
  - A. (6 pts) Please define **serializable schedule** and **serial schedule**.
  - B. (6 pts) Please define **two-phase locking** and **strict two-phase locking** for concurrency control.
  - C. (4 pts) Please explain the reason that the transaction schedules are serializable when two-phase locking is used for concurrency control.
  - D. (4 pts) Suppose that two processes,  $P_1$  and  $P_2$ , read and write a data object D. In other words, there are four locks,  $R(P_1, D)$ ,  $R(P_2, D)$ ,  $W(P_1, D)$ , and  $W(P_2, D)$ . Please provide an example schedule causing deadlock when two-phase locking is used.
  
6. (18 pts) In distributed systems, it is very often that a coordinator is needed to synchronize the work among the processes in the systems. Election algorithms such as bully and ring-based algorithms are designed to determine which process

is the coordinator process. Assume that there are  $n$  processes in the system and each process has a unique label. Please answer the following questions:

- A. In the conventional ring-based election algorithm, a unidirectional ring is used. What is the number of messages needed in worst case and in average to elect a new coordinator when only the coordinator process fails? (10 pts)
- B. In order to shorten the time to elect the new coordinator for ring-based election algorithm, Bob suggests to use a bidirectional ring. Can the election algorithm be made more efficient? If no, explain why. If yes, suggest such an algorithm and compare the number of messages needed for electing a coordinator in the two algorithms. (8 pts)