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1. Assuming that we have a 5-stage pipeline processor implementing MIPS like ISA. The pipeline implements a forwarding unit to reduce stalls due to data dependency. Answer the following questions for the following instruction sequences:

   I1:　add r3, r5, r6　// first instruction to enter pipeline
   I2:　sub r3, r2, r3
   I3:　and r1, r3, r4
   ....

   a. At which stage shall we place the forwarding unit, why?(5%)

   b. The forwarding unit outputs the appropriate multiplexing signals to select the correct data for computation. In your own words, describe the logic of this forwarding unit. Do not show the hazard condition equations.(10%)

   c. Show the forwarding design in the pipeline and detail the necessary information for this functionality.(10 %)

   d. In the above sequence, the "and r1, r3, r4," will receive the data for r3 from which instruction, and from which pipeline stage?(5%)

2. Fill in the best appropriate answer for each of the following questions. (Only accept answers in English.)

   a. When the same object is accessed by two addresses, for instance, two virtual addresses for the same physical page in virtual memory, we call this address _____.(5%)

   b. A _____ is a changing of the internal state of processor to allow a different process to use the processor.(5%)

   c. A cache miss which is caused by the first access to a block that has never been in the cache is called a _____ miss.(5%)

   d. The virtual memory treats the main memory as a fully set associative cache which uses _____ policy for handing write hits.(5%)

3. Which of the functionalities listed below need to be supported by the operating system for the following two settings: (1) handheld devices and (2) real-time systems. (4%)

   a. Batch programming
   b. Virtual memory
   c. Time sharing

4. Discuss the tradeoff between fairness and throughput of operations in the readers-writers problem. Propose a method for solving the readers-writers problem without causing starvation.(4%)

（背面仍有題目，請繼續作答）

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5. (a) What are the advantages and disadvantages of writing an operating system in a high-level language, such as C? (4%)

　(b) Linux runs on a variety of hardware platforms. What steps must the Linux developers take to ensure that the system is portable to different processors and memory-management architectures, and to minimize the amount of architecture-specific kernel code? (4%)

6. (a) What is a virtual machine. (4%)

　(b) What is the main advantage for an operating system designer of using a virtual machine architecture? What is the main advantage for a user? (4%)

7. (a) A thread library provides the programmer an API for creating and managing threads. Please describe how to implement a thread library. (4%)

　(b) Please describe the actions taken by a thread library to context switch between user-level threads. (4%)

8. In the CPU scheduling of the symmetry multiprocessing (SMP) system, each processor is self-scheduling. Please discuss issues concerning SMP systems.
(a) Processor affinity. (3%)
(b) Load balancing. (3%)
(c) Symmetric multithreading. (2%)

9. Consider a demand-paging system with the following time-measured utilizations:

　　　　CPU utilization　　　20%
　　　　Paging disk　　97.7%
　　　　Other I/O devices　5%

For each of the following, say whether it will (or is likely to) improve CPU utilization. Explain your answer.
　　a. Install a faster CPU. (1%)
　　b. Install a bigger paging disk. (1%)
　　c. Increase the degree of multiprogramming. (1%)
　　d. Decrease the degree of multiprogramming. (1%)
　　e. Install more main memory. (1%)
　　f. Install a faster hard disk or multiple controllers with multiple hard disks. (1%)
　　g. Add prepaging to the page fetch algorithms. (2%)
　　h. Increase the page size. (2%)