PRINT FAMILY NAME, GIVEN NAME:________________________

Examination 2
COP 5615 (CSR 740-R) - Operating System Principles
15 April 1999

Instructions:

- **Read all these instructions; failure to follow instructions will result in loss of points.**
- Do not start the examination until instructed to do so.
- This test is open book, open notes.
- **Answer any three (3) questions below.**
- **Start the answer to each question on a new page** (i.e., do NOT put the answer to more than one question on the same page).
- Show your work.
- **Assemble your answers in numerical order of the questions when you submit them.**
- **Leave a 1" square in the upper left corner for a staple.**
- Be sure to include your name on your answer sheets.
- You have 50 minutes to complete this examination.
- **Read and sign the following statement.** You may write this on your exam and sign it there if you wish to take the exam questions home with you today. Do not discuss this exam with anyone in this course who has not yet taken this exam.

On my honor, I have neither given nor received unauthorized aid on this examination, and I will not discuss the contents of this examination with any student who has not yet taken this examination.

Signed:

1. (a) (2) What type(s) of transparency should be achieved by mounting in a distributed file system? Give example(s).
   (b) (4) What is mounting in a file system? Describe what the mount operation and the file name resolution operation must do together to achieve the desired transparency.
   (c) (4) In what ways does mounting in a distributed file system differ from mounting in a local (single host) file system? Be specific. How are these differences handled?

2. In addition to replication, a file system may also have caching at each host or at each process.
   (a) (4) Compare per-host caching vs. per-process caching for file access.
   (b) (6) How does caching interact with the three types of file sharing semantics described? What combinations of strategies for cache update vs. replica update are appropriate for each semantics?

3. (a) (2) Compare the notion of quorums in distributed mutual exclusion and in replica management.
   (b) (2) If there are N replicas, each with one vote, what is the minimum write quorum size? What is the minimum read quorum size if the write quorum size is minimized?
   (c) (2) Justify the quorum size constraints for read-write conflict and write-write conflict.
   (d) (2) Is there any advantage to having a non-minimal read quorum? If so, what is it, if not, why not?
   (e) (2) What should happen if the only RM that has the largest version number in a particular read operation's read quorum happens to be a witness?

4. (a) (3) How can broadcast hardware make the job of memory coherence managers easier in a distributed shared memory system?
   (b) (3) Why is it desirable to update the master copy first when there are replicated shared-read-write blocks using the write-update protocol? What type of system would it be if the write-invalidate protocol is used instead?
   (c) (4) Consider a cache system in which there are 3 processors that may share a given block, with an initial state in which a global store statically holds the master copy and no processor has a valid replica. Assuming a write-invalidate protocol, show the state of each replicated cache block structure (including the global store's) after each of the following operations: p1:read; p2:read; p2:write; p3:write; p1:read; p1:read. You may use the figure below.

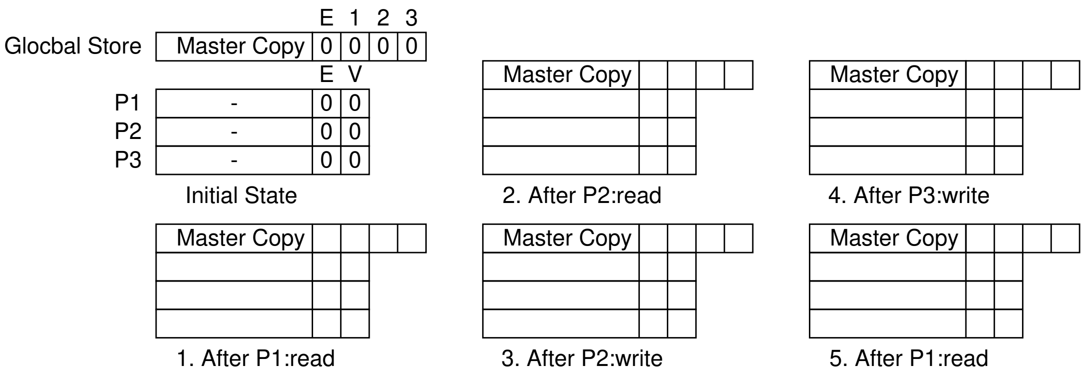

Figure 1: Replicated Cache Block Structures

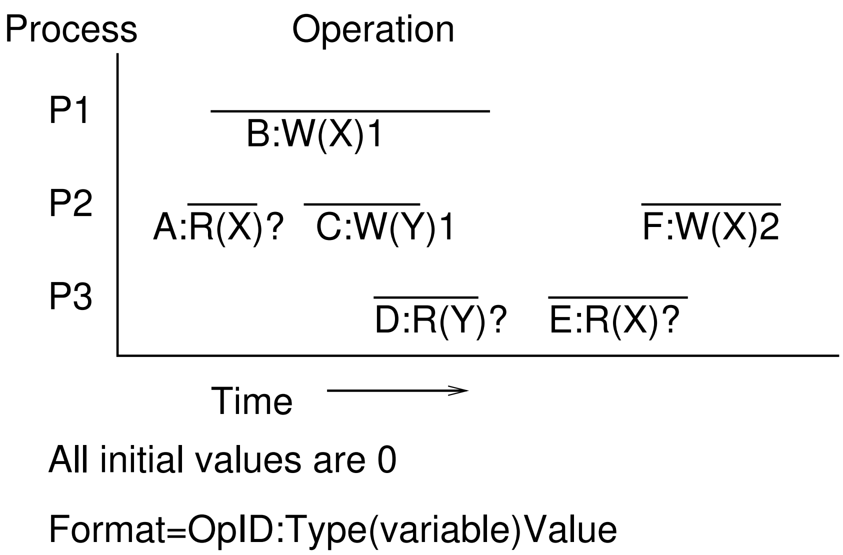

Figure 2: Read and Write operations for consistency question

5. Refer to the figure above for this question.
   (a) (4) Give all possible triples of values that can be returned by reads A, D and E under atomic consistency, along with an order for each triple that produces those values.
   (b) (4) Give any additional possible triples of values that can be returned by reads A, D and E under sequential consistency, along with an order for each triple that produces those values. If there are any triples that cannot occur under sequential consistency, show why they cannot occur.
   (c) (2) Give any additional possible triples of values that can be returned by reads A, D and E under causal consistency, along with a scenario for each triple that produces those values. If there are any triples that cannot occur under causal consistency, show why they cannot occur.

6. (a) (2) Why is MAC usually specified in terms of information flow instead of access control?
   (b) (4) Consider two non-linear lattice systems, each with two compartments. System S_1 has compartments A and B, system S_2 has compartments X and Y. What system is the result of the Cartesian product of S_1 and S_2. Give the access rule for information flow in the new system. To what simple system is the Cartesian product equivalent?
   (c) (4) Consider two linear lattice systems, each with N levels. What type of system is the result of the Cartesian product of these two systems? Give the access rule for information flow in the new system.

7. (a) (2) Why is cryptography central to security in distributed systems?
   (b) (3) What are the main limitations of cryptographic solutions in distributed systems?
   (c) (3) In the Kerberos system, what is the point of separating the Authentication Server from the Ticket Granting Server?
   (d) (2) Compare the Kerberos approach to various implementations of the ACM model; which implementation approach does it most closely resemble? Justify your answer.