Final Examination
COP 5615 - Operating System Principles
16 December 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.
- You have 120 minutes to complete the examination.
- This test is closed book, closed notes, but you may use one 8.5” by 11” crib sheet (both sides).
- Answer any FOUR (4) 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.
- 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: 

Printed Name:
1. (a) (3) Describe the normal operation of the network time protocol that uses intervals rather than a single number to report their time.
   
   (b) (3) What should happen if a single process has an interval that does not overlap with any other process’ interval? Include the behavior of the outlyer as well as that of the other processes.
   
   (c) (3) What may happen in the above protocol when many of the process intervals do not overlap? Give an example to illustrate.
   
   (d) (6) Suggest changes to the protocol that could improve the protocol’s behavior under these circumstances. Give examples to show how your remedy works under extreme circumstances.

2. Consider the Gossip protocol as described in the text.

(a) (2) Is the vector timestamp assigned by an FSA to an update unique? Explain.

(b) (2) Is the vector timestamp $V$ on a replica of an object unique? Explain.

(c) (2) Is the vector timestamp $R$ of a replica manager unique? Explain.

(d) (2) How does a replica manager know whether it can apply an update to its copy of an object?

(e) (7) Consider the following scenario. All timestamps are initialized to $<0,0,0>$.  

i. $FSA_1$ reads from $RM_1$ then writes $u_1$ to $RM_1$.

ii. $FSA_2$ reads from $RM_1$ then writes $u_2$ to $RM_2$.

iii. $FSA_2$ then writes $u_3$ to $RM_3$.

iv. $FSA_3$ reads from $RM_1$ then writes $u_4$ to $RM_3$.

v. $FSA_4$ reads from $RM_3$ then writes $u_5$ to $RM_1$.

vi. $FSA_3$ reads from $RM_2$ then writes $u_6$ to $RM_5$.

vii. $FSA_2$ then writes $u_7$ to $RM_1$.

viii. $RM_5$ gossips to $RM_1$, then $RM_1$ gossips to $RM_2$.

Depict this scenario with at time-space diagram on a separate sheet of paper, including $V$ and $R$ at each $RM$ after each update arrives and then after any processing that may have occurred. Assuming that updates that can be processed are processed before the next read or update occurs. Include timestamps on each update and at each $FSA$ as they are updated. Indicate whether an update is rejected (RJ), processed (PR), or logged (LG) at its receipt. Logged updates are processed as soon as possible - indicate when this occurs with PR $i$, where $i$ is the update number. Show the log at each $RM$ before and after the gossips take place.

3. (a) (2) What is the priority inversion problem? Why is it a problem?

(b) (3) How does PIP handle priority inversion? Give a good example.

(c) (5) What problem does the PCP attempt to solve? How does PCP attempt to solve it (describe PCP and explain how this is supposed to solve the problem)?

(d) (2) What new problems may PCP introduce? Give an example scenario.

(e) (3) What happens if a process can only request locks in order of their priority ceiling, from lowest to highest, with some total order to break ties among locks with the same priority ceiling? Does this approach solve any problems?
4. (a) (4) What relationship applies to the choice between replication or migration on read or write vis-a-vis write-invalidate or write-update. Explain.
(b) (3) Write-invalidate is used more often than write-update. Why?
(c) (3) When is write-update better than write-invalidate, and why?
(d) (5) If you were to model these two approaches quantitatively, what factors would you take into consideration and how would you model them to determine which approach is better under a given set of circumstances.

5. (a) (4) Describe the Broadcast protocol for Distributed Mutual Exclusion (B/DME).
(b) (4) What effect can loss of messages have on the B/DME? Show all possible results of message loss with examples.
(c) (4) How can the B/DME be augmented to mitigate some of the potential bad outcomes of message loss? Show how your augmentation works.
(d) (3) What philosophical and practical differences are there between DME and Leader Election?

6. (a) (3) Explain integrity issues in information flow security as you might to an intelligent high school student.
(b) (4) What is the most critical problem in use of symmetric cryptography systems in distributed systems? Why? What is it for asymmetric cryptosystems? Why?
(c) (3) How are compartmented lattice systems useful? Give an example that you might use to explain this to your mother.
(d) (5) Consider two compartmented lattice-based security models, the first with compartments A and B, the second with compartments X and Y. Give a mathematical description of the product of these two lattices. To what lattice system is the product lattice isomorphic? Show it.