DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

6.033—Computer System Engineering Handout #32—April 29, 1994

QUIZ #3. 2–3 p.m., rooms 34-101, 36-144, 36-153, and 36-156

This quiz contains **seven** problems whose relative weights are indicated by the number of points each is assigned. Please place each answer on the page with the question and hand in this booklet at the end of the examination.

As usual, beware: some parts of some problems are much harder than others. Read them all through first and attack them in the order that allows you to make the most progress. Write down any assumptions and show your work, or you risk losing partial credit. Be neat. If we can't figure out your answer we can't give you credit. For problems that require a numerical answer, be sure to indicate the units of your answer.

Under penalty of major embarrassment if you don't, circle your recitation instance and write your name at the bottom of the page!

1. 10:00—Tennenhouse/McDonald
2. 11:00—Tennenhouse/DeHon
3. 1:00—Kaashoek/Manning
4. 2:00—Kaashoek/Joseph
5. 11:00—Corbató/McDonald
6. 12:00—Waldspurger/DeHon
7. 11:00—Waldspurger/Manning
8. 1:00—Corbató/Joseph

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Problem	Your Score	Maximum Score
1		20
2		18
3		20
4-5-6		22
7		20
Total		100

 Name _____

Problem 1. *(20 points)* You are examining a 3.5-inch magnetic disk that spins at 7500 RPM, with an average seek time of 6 milliseconds and a data transfer rate of 2 Megabytes/second.

a. How long does it take to read a block of 4 Kilobytes chosen at random?

Suppose that the operating system maintains a one-Megabyte cache in RAM that hold disk blocks. The access time to this cache is 125 nanoseconds and the data transfer rate is 20 Megabytes/second.

b. Give the formula that tells the average time to read a 4 Kilobyte disk block, assuming that the hit-ratio of the disk block cache is h.

c. Ben Bitdiddle's workstation has 24 Megabytes of RAM. To increase h, Ben reconfigures the disk block cache to be much larger than one Megabyte. To his surprise he discovers that many of his applications now run slower rather than faster. What has Ben probably overlooked?

d. Louis Reasoner has gone over to the Lab for Computer Science and has disassembled your disk unit to see how it works. Remembering that the centrifuge in the biology lab runs at 36,000 RPM, he has come up with a bright idea on how to reduce the rotational latency of the disk. He suggests speeding it up to 96,000 revolutions per minute. He calculates that the rotation time will now be 625 microseconds.

One of the other UROP's in the lab says this idea is crazy. Explain the line of reasoning that the other student probably has in mind.

 Name _____

Problem 2. (18 points)

Your company has asked you to take the responsibility for developing a storage system for a very demanding application, so you have decided to use a triplexed stable-storage scheme. You will use three ordinary disk drives D1, D2, and D3, and arrange that D2 and D3 store identical copies of each block stored on D1. The disk drives are of a very simple design that does not report read errors. That is, they just return data, whether or not it is valid.

a. You initially construct the application so that it writes a block of data to all three drives concurrently. After a crash occurs during the middle of a write, you are unable to reconstruct the correct data for that block. What is the problem?

b. Describe a simple modification to solve this problem.

c. One day there is a really awful power glitch that crashes all three disks in such a way that each disk corrupts one random track. Fortunately, the system wasn't writing any data at the time. Describe a procedure for reconstructing the data. Explain any cases that your procedure cannot handle.

 Name _____

3. *(20 points)* A system that implements atomic operations writes the following types of records to a log maintained on stable storage:

<AO_i ***start***>	Atomic operation *i* starts.
<AO_i, *x, old, new*>	Atomic operation *i* writes the value *new* over the value *old* for the variable named *x*.
<AO_i ***commit***>	Atomic operation i commits.
<AO_i ***abort***>	Atomic operation i aborts.
<AO_i, AO_j, … AO_k; ***checkpoint***>	At this instant, atomic operations i, j,…k are uncommitted.

Atomic operations start in numerical order. A crash occurs, and the recovery procedure scans the log backwards to the latest checkpoint, finding the following records:

<AO_7, AO_{41}, AO_{42}; ***checkpoint***>
<AO_{43} ***start***>
<AO_{44} ***start***>
<AO_{43}, y, 5, 6>
<AO_{43}, x, 5, 9>
<AO_{43}, ***commit***>
<AO_{44}, y, 6, 4>
<AO_{45} ***start***>
<AO_{45}, z, 3, 4>
<AO_7 ***abort***>
<AO_{41}, q, 1, 9>
<AO_{46} ***start***>
<AO_{45}, y, 4, 3>
<AO_{44} ***commit***>
<AO_{45}, y, 3, 7>
<AO_{41} ***commit***>
<AO_{47} ***start***>
<AO_{46} x, 9, 2>
<AO_{46} w, 0, 1>
<AO_{46} ***commit***>
<AO_{47}, u, 2, 1>
(***** crash happened here *****)

a. How much farther back in the log should the recovery procedure scan?

b. Which atomic operations mentioned in this part of the log are *winners* and which are *losers*?

winners: losers:

c. Is it possible to make the list of losers complete with just the information given?

Yes/No

d. What are the values of x and y immediately after the recovery procedure finishes? Why?
x = Because:
y = Because:

 Name _____

4. *(5 points)* The log of problem 3 contains (ambiguous) evidence that someone didn't follow coordination rules. What is the evidence?

5. *(5 points)* The intentions-list logging protocol requires that the commit (or abort) record should be written to the log BEFORE any updates to cell storage are made. Identify the best reason for this requirement.

_____ 1. So that the recovery manager knows what to undo.
_____ 2. So that the recovery manager knows what to redo.
_____ 3. Because the log is less likely to fail than the cell storage.
_____ 4. To minimize the number of disk seeks required.

6. *(12 points)* Brooks describes several interesting effects, three of which are listed below:

a. The mythical man-month.
b. The second-system effect.
c. Plan to throw one away.

Following are several root causes. Indicate beside each one the letter of the one effect it is most likely to cause.

_____ 1. training time
_____ 2. the first system is likely to be quite spartan
_____ 3. additional communication
_____ 4. a second system is likely to have better modularity
_____ 5. repartitioning effort
_____ 6. each idea looks good in isolation

7. Pat, Diane, and Quincy are having trouble using e-mail to schedule meetings of their 6.033 case study group. Pat suggests that they take inspiration from the 2-phase commit protocol.

(15 points) Which of the following most closely resembles 2-phase commit? (Circle the appropriate Roman numeral.)

I. a. Pat requests everyone's schedule openings.
b. Everyone replies with a list but does not guarantee to hold all the times available.
c. Pat inspects the lists and looks for an open time.
If there is a time,
Pat chooses a meeting time and sends it to everyone.
Otherwise
Pat sends a message canceling the meeting.

II. a-c, as in protocol I.
d. Everyone, if they received the second message,
acknowledges receipt.
Otherwise
sends a message to Pat asking what happened.

III. a-c, as in protocol I.
d. Everyone, if their calendar is still open at the chosen time
Send Pat an acknowledgement.
Otherwise
Send Pat apologies.
e. Pat collects the acknowledgements. If all are positive
Send a message to everyone saying the meeting is ON.
Otherwise
Send a message to everyone saying the meeting is OFF.
f. Everyone, if they received the ON/OFF message,
acknowledges receipt.
Otherwise
sends a message to Pat asking what happened.

IV. a-f, as in protocol III.
g. Pat sends a message telling everyone that everyone has confirmed.
h. Everyone acknowledges the confirmation.

(5 points) Below, circle the letter of the step that commits the meeting time.

a b c d e f g h