Department of Electrical Engineering and Computer Science

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

6.033 Computer Systems Engineering: Spring 2012

Quiz 2

There are 12 questions and 9 pages in this quiz booklet. Answer each question according to the instructions given. You have **50 minutes** to answer the questions.

Some questions are harder than others and some questions earn more points than others—you may want to skim all questions before starting.

For true/false questions, you will receive 0 points for no answer, and negative points for an incorrect answer. Do not guess; if you are unsure about your answer, consult your notes. We will round up the score for every *numbered* question to 0 if it's otherwise negative (i.e., you cannot get less than 0 on a numbered question).

If you find a question ambiguous, be sure to write down any assumptions you make. **Be neat and legible.** If we can't understand your answer, we can't give you credit!

Write your name in the space below. Write your initials at the bottom of each page.

THIS IS AN OPEN BOOK, OPEN NOTES, OPEN LAPTOP QUIZ, BUT DON'T USE YOUR LAPTOP FOR COMMUNICATION WITH OTHERS.

CIRCLE your recitation section number:

10:00	1. Rudolph/Grusecki		
11:00	2. Rudolph/Grusecki	3. Abelson/Gokce	4. Katabi/Joshi
12:00		5. Abelson/Gokce	6. Katabi/Joshi
1:00	7. Shavit/Moll	8. Szolovits/Fang	
2:00	9. Shavit/Moll	10. Szolovits/Fang	

Do not write in the boxes below

1-3 (xx/26)	4-7 (xx/26)	8 (xx/12)	9 (xx/18)	10-12 (xx/18)	Total (xx/100)

Name:

I Reading Questions

1. [10 points]: Answer the following question based on the paper "Do incentives build robustness in BitTorrent?". The main feature that distinguishes BitTyrant from BitTorrent is:

(Circle the BEST answer)

A. Data transfers with BitTyrant clients are all transactions.

B. BitTyrant data transfers can be rolled back.

C. BitTyrant clients find their peers with the use of distributed hash tables.

D. BitTyrant clients choose their peers in a way that leads them towards downloading more information than they upload.

E. BitTyrant's algorithms model altruism by using cumulative distribution functions (CDF).

2. [8 points]: Choose the correct statement about System R's recovery process, based on the paper you read in recitation.

(Circle the BEST answer)

A. During the recovery process in system R there is a complete redo of all transactions that were committed after the checkpoint, and for uncommitted transactions there is an undo of the parts that happened before the last checkpoint.

B. During the recovery process in system R there is a complete redo of all transactions that were committed after the checkpoint, and for uncommitted transactions there is a redo of the parts that happened before the last checkpoint.

C. During the recovery process in system R there is a complete redo of all transactions that were committed after the checkpoint, and for uncommitted transactions there is an undo of the parts that happened after the last checkpoint.

D. During the recovery process in system R there is a complete redo of all transactions that were committed after the checkpoint, and a complete undo of all uncommitted transactions.

3. [8 points]: In the LFS system, as described in the paper that you read in recitation, what is the commit point, meaning the point at which a single data block overwritten in a file will be available after a crash, assuming that there are no software bugs and the contents of the disk survive the crash?

(Circle the BEST answer)

A. The application's `write()` system call returns.

B. The application calls `close()` on the file.

C. The file's data block is flushed to the log.

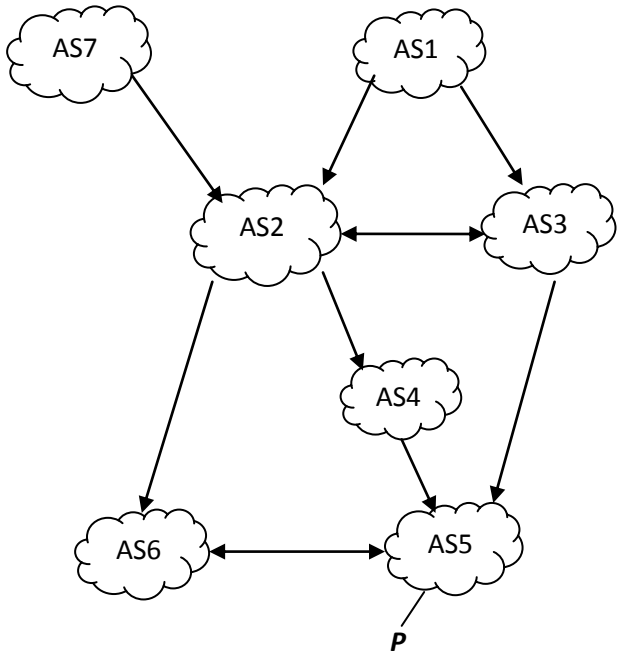
D. The file's updated inode is flushed to the log.

E. The segment summary for the segment containing the file's data and updated inode is flushed to the log.

F. The checkpoint region is updated to include the location of the updated inode.

II BGP

Consider the topology below, where arrows point from provider to customer and bi-directional arrows refer to a peering links. Assume that the ASes follow the import and export rules described in the required reading titled "Wide-Area Internet Routing". The figure shows that the address prefix P belongs to AS 5.



Answer the questions on the next page.

Initials:

4. [5 points]: Which AS path does AS1 follow to reach prefix P in AS5? You only need to list the ASes on the path in order, starting with AS1 and ending with AS5.

AS1 → → AS5

5. [5 points]: How many paths does AS2 learn for prefix P? Which of these AS paths does it use to deliver packets to prefix P? Again, write the path as an ordered list of ASes.

Number of paths:

AS2 → → AS5

6. [8 points]: Say that the link between AS2 and AS4 and the link between AS6 and AS5 both fail. Would any of the ASes in the figure lose the ability to reach prefix P (i.e., will have no routes to P even after the routing stabilizes)? If "yes", tell us which AS or ASes?

7. [8 points]: Say that the topology is as in the Figure except that the link between AS2 and AS3 fails (this is the only link that fails). Let the routes stabilize after the failure. Does any of the ASes change the route it uses to reach prefix P before and after the failure? If "yes", which AS, and what is the new route?

III Fault-tolerance

8. [12 points]: Alyssa P. Hacker stores her data on a fault-tolerant storage system, which has 5 1 TB disks that together provide 4 TB of aggregate space, and can tolerate any one (but no more) disk failure. Each disk has a MTTF of 10^6 hours, and you can assume that all disk failures are independent. When a disk fails, Alyssa orders a replacement from Amazon which arrives in approximately 4 days (100 hours). Once Alyssa plugs in the replacement disk, assume that its content is reconstructed instantaneously. What is the MTTF for Alyssa's storage system?

(Circle the BEST answer)

A. 10^6 hours

B. 4×10^7 hours

C. 5×10^8 hours

D. 2×10^9 hours

E. 10^{10} hours

IV Isolation

9. [18 points]: Alyssa P. Hacker switches her transactional system to a weaker isolation mode, where one transaction that's still running can observe the effects of any other committed transaction, even if that committed transaction started later. (In Postgres, this is called `READ COMMITTED`.) Alyssa runs two transactions, `xfer(A, B, 10)` and `audit(50)`, whose code is below, both of which eventually commit but can run concurrently:

```
xfer(a, b, amt):
  accounts[a].balance = accounts[a].balance - amt
  accounts[b].balance = accounts[b].balance + amt

audit(thresh):
  for a in accounts:
    if a.balance > thresh:
      sum += a.balance
  return sum
```

Every reference to the `balance` field of an account is a separate read or write. Do not make any assumptions about the order in which `audit` iterates over the accounts. The database starts in the following state:

Account	*Balance*
A	55
B	45

Which of the following tuples of values (A, B, audit), representing the final state of the database and the return value of the `audit` function, can result after running these two transactions in Alice's weaker isolation mode?

(Circle True or False for each choice.)

A. True / False A=45, B=55, audit=0

B. True / False A=45, B=55, audit=45

C. True / False A=45, B=55, audit=55

D. True / False A=45, B=55, audit=90

E. True / False A=45, B=55, audit=100

F. True / False A=45, B=55, audit=110

Initials:

V Performance

Ben Bitdiddle runs the database for a credit card processing company. Ben's clients are online stores that each have a single program running the following pseudocode to charge customer credit cards:

```
while True:
  ccnum, amount = get_next_order()
  send(ben, {ccnum, amount})
  status = recv(ben)
```

Ben's server looks like the following pseudocode, where `write_log()` prepares the log records, but only `flush_log()` writes to disk. Assume that every log flush requires seeking to a new location. Assume that `reply()` does not block.

```
while True:
  ccnum, amount = recv()
  status = check(ccnum, amount)
  if status == OK:
    write_log(ccnum, amount)
    flush_log()
  reply(status)
```

Ben's database must commit each credit card charge operation before responding to the client. Ben uses a typical rotational disk, with a 10 msec average seek time, and 100 MB/sec sequential throughput. Each log record is 512 bytes. The round-trip latency between each client and the server is 100 msec. Assume that the `check()` function is instantaneous.

10. [4 points]: How many credit cards can Ben's system successfully charge per second, if Ben has a large number of clients?

11. [6 points]: How many credit cards can Ben's system successfully charge per second, if Ben has 5 clients, the clients spend almost no time in `get_next_order()`, and `get_next_order()` never blocks?

Initials:

Ben decides that he wants to process more transactions per second, and changes the server code to flush the log after a batch of records have been written to the log:

```
while True:
  for i = 1..N:
    ccnum[i], amount[i] = recv()
  for i = 1..N:
    status[i] = check(ccnum[i], amount[i])
    if status[i] == OK:
      write_log(ccnum[i], amount[i])
  flush_log()
  for i = 1..N:
    reply(status[i])
```

12. [8 points]: How many credit cards can Ben's modified system successfully charge per second, if Ben has a large number of clients? Assume the best choice of N.

End of Quiz II

Double-check that you wrote your name on the front of the quiz, and circled your recitation.

Initials: