CSE 452/M552 Problem Set 3
Due: Friday June 1, 11:59pm
Solutions must be typeset and include your name.
Solutions must be done individually.

Problem 1: PMMC/Lab 3

To be elected a new leader in PMMC, the leader must receive responses from a majority of acceptors. Each acceptor responds with the latest accepted proposal (and value) for every slot or position in the state machine log. Assume the leader is successfully elected (receives responses from a majority). This question concerns what the leader knows prior to taking any further action. In a sentence, explain why:

a) For a given slot, the same value can have been accepted by a majority of acceptors, but not (yet) be chosen.

b) For a given slot, the new leader can for the first time learn that a value is chosen for a specific slot.

c) If the new leader learns that a value has been chosen in slot i, it may not (yet) know whether a different value has been chosen for the preceding slot.

d) If the new leader learns that a value has been chosen in slot i, it may not (yet) know the value of any accepted proposals for the preceding slot.

e) The new leader may learn that the same value has been chosen for two different slots.

Problem 2: Memcache

Facebook's initial design managed its memcache servers as a "lookaside" cache. When rendering an object on a page, the front-end first sends a message to the relevant memcache server; if the data is not available (or if the request packet is lost), the front-end (not the cache) retrieves the data from the relevant storage server and then stores the fetched data into the memcache server. On update, the front-end invalidates the cached copy (if any) and updates the storage server.

In a sentence, explain why:

a) Even if all messages are delivered (there are no timeouts and there are no node failures), a read started after a write completes (both the storage server write and the invalidation) might return data that is inconsistent with what is stored at the storage server.

b) To reduce the frequency of inconsistent reads, Facebook introduced a read token, set on a cache miss. Subsequent writes invalidate the read token, so that when the reader attempts to fill the cache with the missing data, it will only be able to do so if there was no intervening write. Explain why (a) is no longer true.
Problem 3: BigTable

Consider a BigTable client whose cache is empty—it has never talked to this BigTable deployment before. Enumerate the requests it will make to read a single row with key k from table T.

Problem 4: GFS

Give one scenario where GFS’s “record append” would insert duplicate records at the end of a file.

Problem 5: Dynamo

Consider a cluster of 100 Dynamo nodes with the following parameters: \( N=3, \, W=3, \, R=3 \). Dynamo picks as the write coordinator the node that responded fastest to the previous client read. In a sentence, explain why this system is not linearizable.