Concurrent and Distributed Systems: Supervision 4

Lectures covered by the supervision: [https://www.cl.cam.ac.uk/teaching/2223/ConcDisSys/](https://www.cl.cam.ac.uk/teaching/2223/ConcDisSys/)

- Lecture 13: Replication, Quorums, State machine replication
- Lecture 14: Consensus, Raft
- Lecture 15: Two-phase commit, Linearizability, Eventual consistency
- Lecture 16: Collaboration, Spanner

Previous exams.

Supervision questions:

1. Discuss total order broadcast and FIFO-total order broadcast.
2. Define and discuss (with examples) the properties of:
   a. Replication
   b. Quorums
   c. Consensus
   d. Linearizability
   e. Eventual consistency
3. Discuss common issues with:
   a. Replication
   b. Linearizability
   c. Consistency
4. Discuss the problem with Twitter mentioned in the lecture. Why was the number of followers a negative number?
5. Describe the motivation behind the state machine replication, its implementation, and its challenges.
6. Discuss two-phase commit.
7. Discuss Raft algorithm.
8. Three nodes are executing the Raft algorithm. At one point in time, each node has the log shown below (Figure 1):

   ![Figure 1: Raft example.](image)

   a. Explain what events may have occurred that caused the nodes to be in this state.
   b. What are the possible values of the commitLength variable at each node?
   c. Node A starts a leader election in term 4, while the nodes are in the state above. Is it possible for it to obtain a quorum of votes? What if the election was instead started by one of the other nodes?
   d. Assume that node B is elected leader in term 4, while the nodes are in the state above. Give the sequence of messages exchanged between B and C following this election.
9. Is the execution below (Figure 2) linearizable? If not, where does the violation occur?
10. Discuss CRDT and its variations.
11. Discuss Operational Transformation.
12. Give pseudocode for a variant of the operation-based map CRDT algorithm that has multivalue register semantics instead of last-writer-wins semantics; that is, when there are several concurrent updates for the same key, the algorithm should preserve all of those updates rather than preserving only the one with the greatest timestamp.
13. Discuss the CAP theorem.
14. Discuss consistency properties of Google’s Spanner and techniques that were used to achieve them.
15. Discuss TrueTime and what are techniques that enable its implementation.
16. Create a summary of the course:
   a. Identify problems specific to concurrent systems and problems specific to distributed systems.
   b. Identify common challenges in concurrent and distributed systems.
   c. Identify common abstract solutions to these challenges.
   d. Map the abstract solutions to concrete instances of solutions discussed in concurrent systems and in distributed systems.
20. Summarize in 1-3 sentences Lecture 16.

Save your answers into MS Teams or email them to me. Please use the following naming pattern: CDS_Supervision_4_Answers_<last name>_<first name>_Michaelmas_2022

Send your answers as a pdf, doc, image, or any other format of a document for which there exists an easily available software to open.

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