

1. *10 marks*

Construct a solution to reliable, totally ordered multicast in a synchronous system, using a reliable multicast and a solution to the consensus problem.

2. *5 marks*

- (a) Can Byzantine agreement be reached for 8 generals, with 3 of them faulty?
- (b) Can Byzantine agreement be reached for 8 generals, with 3 of them faulty, if the generals digitally sign their messages?

3. *8 marks*

A three-phase commit protocol has the following parts

Phase 1: is the same as the two-phase commit.

Phase 2: the coordinator collects the votes and makes a decision; if it is No, it aborts and informs participants that voted Yes, if the decision is Yes, it sends a precommit request to all participants. Participants that voted Yes wait for a precommit or doAbort request. They acknowledge precommit requests and carry out doAbort requests.

Phase 3: the coordinator collects the acknowledgements. When all are received, it commits and sends a do commit to the participants. Participants wait for a doCommit request. When it arrives they Commit.

Explain how this protocol avoids delay to participants during their "uncertain" period due to the failure of the coordinator or other participants. Assume that communication does not fail.

4. *10 marks*

A processor P is part of a network $G(V, E)$. P believes that processor Q is also connected to the network. Describe a protocol that P together with the other processors of the network can use in order to find Q or to find that Q is not part of the network. Prove the time complexity of the algorithm.

5. *15 marks*

Give a solution to the dining philosophers problem. Prove the time complexity of the algorithm.

6. *12 marks* :

A quorum consensus method with three replicas is used for replication. The parameters of the replication system are described in the following table. Calculate: i) the read latency, ii) the write latency, iii) the blocking probability of a read and iv) the blocking probability of a write.