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 hat voted Yes, if the decision is Yes, it sends a precommit request to all participants. Participants that voted Yes wait for a precommit or doAbord 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 he 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*

   Describe an implement a distributed LIFO queue that tolerates 2 replica crashes for both *enqueue* and *dequeue* operations.item *15 marks*

5. *15 marks*

   (a) Show that the protocol given below is not a correct solution to the mutual exclusion problem for a system with two processes, P and Q.