

Distributed Computing

Date: 06.05.2025

Duration: 3 hours

Max marks: 100

Answer as many questions as possible. Only precise answer will get full mark(s).

1. Define the following concepts related to random walks on graphs: (i) simple random walk, (ii) stationary distribution, and (iii) mixing time. Suppose a piece of information (or a token) is initially placed at a node in an n -node complete network. The goal is to spread the information to all nodes via the random walk process. Analyze the time it takes for the token to reach all nodes. [12 + 10]
2. Define Byzantine agreement. Consider a synchronous message passing distributed system of n nodes, fully connected and at most $n/20$ of them are Byzantine. Design and analyze a constant-round randomized binary Byzantine agreement algorithm. Clearly state any assumptions that you make. [6+14]
3. Consider a message-passing distributed system consisting of n nodes and f of them are Byzantine.
 - (a) Define the Byzantine Leader Election in this setting.
 - (b) Show that it is impossible to solve the Byzantine leader election problem deterministically.
 - (c) Is it always possible to design a randomized algorithm that elects a leader with high probability, i.e., with success probability greater than $1 - 1/n$? Justify your answer with a clear argument. [5 + 7 + 8]
4. Describe the k -machine model. Show that any algorithm in the CONGEST model can be adapted to the k -machine model, but the converse does not hold. [5 + 12]
5. Design and analyze an $O(\log n)$ -rounds algorithm for computing an MST of an input graph in the Congested Clique model. [14+6]
6. Consider an anonymous ring of n nodes, i.e., nodes are indistinguishable. Suppose 3 mobile agents are initially placed at three nodes arbitrarily. Show that if the agents are anonymous (i.e., no IDs), it is impossible to gather them at a single node deterministically. Design a randomized algorithm for gathering and analyze time complexity. You may assume that the agents have memory and two agents can communicate when they are at the same node. [6+14]