Sample Term End Examination - Distributed Systems (CDS3001)

Programme: Integrated M.Tech. **Course Title:** Distributed Systems **Course Code:** CDS3001 **Semester:** WINTER-2024-25 **Max. Marks:** 100 **Duration:** 3 Hours

Instructions: Answer all questions. Assume suitable data if necessary. Draw neat diagrams wherever required.

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1. Fundamental Concepts (15 Marks) a) Define a Distributed System and list its key characteristics and challenges. (5 Marks) b) Explain different types of transparency in a distributed system with examples. (5 Marks) c) Compare and contrast the synchronous and asynchronous distributed system models. Highlight the implications of each model on algorithm design. (5 Marks)

2. Time and Global State (15 Marks) a) Explain Lamport's logical clocks. Consider three processes P1, P2, P3 with the following events: * P1 sends m1 to P2. * P2 receives m1, then sends m2 to P3. * P3 receives m2, then sends m3 to P1. * P1 receives m3. Assign Lamport timestamps to each event, assuming each process increments its clock by 1 for each local or send event. Show the final timestamps. (7 Marks) b) Define a consistent cut and an inconsistent cut in a distributed system using diagrams. Explain the significance of consistent cuts in capturing global states. (8 Marks)

3. Message Ordering and Group Communication (10 Marks) a) Differentiate between FIFO, Causal, and Total message ordering guarantees. Which provides the strongest guarantee? (5 Marks) b) Explain the Birman-Schiper-Stephenson protocol for achieving Causal Ordering of multicast messages. (5 Marks)

4. Distributed Mutual Exclusion (15 Marks) a) Describe the Ricart-Agrawala algorithm for distributed mutual exclusion. Explain how it uses timestamps to ensure mutual exclusion and fairness. (8 Marks) b) Compare token-based and non-token-based approaches for distributed mutual exclusion in terms of message complexity and fault tolerance. Give one example algorithm for each approach. (7 Marks)

5. Deadlock Handling (10 Marks) a) Explain the concept of a distributed deadlock. Why are traditional single-system deadlock detection algorithms not directly applicable? (4 Marks) b) Describe the Chandy-Misra-Haas edge-chasing algorithm for distributed deadlock detection. Illustrate with a simple Wait-For-Graph (WFG) example. (6 Marks)

6. Replication and Consistency (15 Marks) a) What are the primary motivations for data replication in distributed systems? (5 Marks) b) Explain Sequential Consistency and Causal Consistency models for replicated data. Provide an example execution for each to illustrate their differences. (10 Marks)

7. Fault Tolerance (10 Marks) a) Explain the difference between coordinated and uncoordinated checkpointing for rollback recovery. What is the domino effect, and which approach is susceptible to it? (6 Marks) b) Describe the two-phase commit (2PC) protocol used for atomic commitment in distributed transactions. Discuss its potential blocking problem. (4 Marks)

8. Distributed Shared Memory & File Systems (10 Marks) a) What is Distributed Shared Memory (DSM)? Briefly explain one approach to implementing DSM (e.g., page-based). (5 Marks) b) Briefly describe the architecture and key features of the Network File System (NFS). (5 Marks)
