राष्ट्रीय प्रौद्योगिकी संस्थान पटना National Institute of Technology Patna

End Semester Examination (Online mode) Session: July-December 2021

Department: Computer Science and Engineering

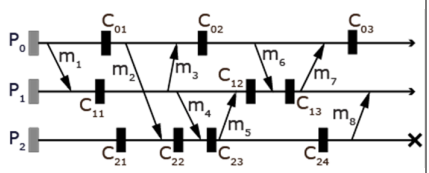
Programme: B.Tech.-CSE Semester: 7th

Course Code: **CS7479** Course: **Distributed Systems**

Full Marks: 40 Duration: 2 hours

[Attempt all questions; Answer concisely only in blue/black ink; Use pencil for artwork; Assume missing data]

[Marks, Course Outcome and Bloom's Level are mentioned on right-hand side of each question]

Sl.	No.	Questions	CO	BL
1.		Consider a distributed system (comprising of processes P_0, P_1 and P_2 residing in separate (but connected) nodes), as shown below. P_0, P_1 and P_2 communicate by exchanging messages, which are depicted as m_1 – m_8 in the figure. The system also implements a checkpointing solution for failure recovery (where each node records uncoordinated and independent checkpoints of process state, depicted as C_{01} – C_{24} in the figure), so that the system can restore back to a consistent state after recovery. 		
	a.	Consider a scenario for the above system, where P_2 fails, as shown in the figure. The system is recovered from this failure and is restored back to a consistent state using preserved checkpoints. Calculate all possible consistent recovery lines (by listing through corresponding checkpoints), and find out which of the recovery lines to adopt. **(5+2)** [Course outcome(s) evaluated: CO-4(Apply/Solve)]	CO-4	Level-3
	b.	Is it possible to use message logging and replay to augment this checkpointing solution to do even better recovery for the system in the above scenario? Justify. **(3)** [Course outcome(s) evaluated: CO-3(Understand/Explain)]	CO-3	Level-2
2.		Consider a distributed system, which is comprised of processes P_1, P_2,..., P_n, and is deployed in a reliable network (with no failures and message losses), running three-phase distributed commit protocol for committing a transaction. Assume that only one process fails at a particular time.		
	a.	Explain how this protocol resolves the situations arising from different cases of process-crash failures of Coordinator — (i) before sending COMMIT_REQ message, (ii) before sending PREPARE/ABORT message, (iii) before sending COMMIT message. **(3 × 2)** [Course outcome(s) evaluated: CO-3(Understand/Explain)]	CO-3	Level-2

	b.	Explain how this protocol resolves the situations arising from different cases of process-crash failures of any single Cohort — (i) before sending AGREED/DISAGREED message, (ii) before sending ACK message. (**2 × 2**) [Course outcome(s) evaluated: CO-3(Understand/Explain)]	CO-3	Level-2
3.		Till 2008, Facebook® has supported passive replication through its two data centers at California and Virginia, primary Replica-Manager being maintained at California, while backup Replica-Manager at Virginia. All write requests and 'unsafe' read requests are handled by primary and 'safe' read requests are diverted to backup. A replication lag of 20 seconds has been considered for update propagation from primary to backup. Based on the above conditions, explain whether each of the following consistency models be supported in the replication of Facebook. (**4 × 2½**) (i) Linearizability; (ii) Sequential consistency; (iii) Causal consistency; (iv) FIFO consistency. [Course outcome(s) evaluated: CO-3(Understand/Explain)]	CO-3	Level-2
4.	a.	Consider a distributed system with concurrently-executing process: P_1, P_2, P_3 (their all statements, shown in the next figure, are assumed to be indivisible). Initial values of the 3 shared data items (in data store): $x = y = z = 0$. For any particular interleaved execution sequence, the signature obtained = "001001", where signature = output of P_1, P_2 and P_3 concatenated in that order. Determine whether the said sequence will result in sequential-consistent data store containing x, y, z. (**6**) [Course outcome(s) evaluated: CO-5(Analyse/Determine)]	CO-5	Level-4
	b.	Describe, with figure, the working of eventual consistency model that Cassandra (which is a highly-available distributed database system) enforces for maintaining consistent data store. (**4**) [Course outcome(s) evaluated: CO-1(Remember/Recall)]	CO-1	Level-1

Process P_1	Process P_2	Process P_3
x ← 1;	y ← 1;	z ← 1;
print(y,z);	print(x,z);	print(x,y);

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