राष्ट्रीय प्रौद्योगिकी संस्थान पटना National Institute of Technology Patna

End Semester Examination (Jul-Dec'20) Session: 2020-21 Autumn'20 Semester

Department: Computer Science and Engineering

Programme: M.Tech-CS(Networks)-1st Sem/Ph.D-1st Sem/Ph.D-2nd Sem

Course Code: **CS420166** Course: **Distributed System Design**

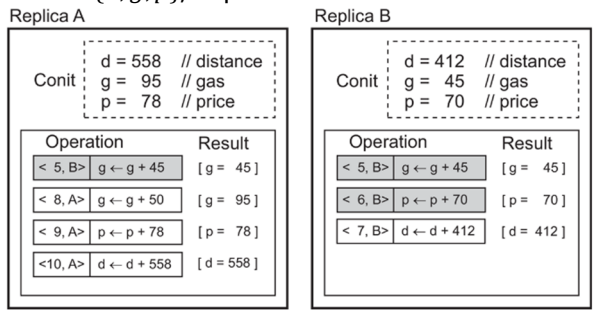
Full Marks: 40 Duration: 2 hours

[Attempt all questions; Answer in your own handwriting using blue/black ink]

[Answer concisely; Use pencil for artwork; Assume missing data]

[Write Roll no., Course code, Page no. at top margin of every page; upload single PDF]

1. a. A cab management company (which provides hospitality service) manages its fleet of vehicles through a replication system, where a conit is defined as set $\{d, g, p\}$, replicated across two servers — Replica A and Replica B. Here, g = amount of fuel refilled in cab, p = price of fuel g, d = total distance covered since last time fuel refilled. At any particular time, the status of the replicas is shown in the figure. What is the numerical deviation at replica A? (2)



(i) (2,558). (ii) (2,482). (iii) (2,686). (iv) (3,686).

1. b. If a resource R is working ¾ of its time and is down for the rest of time (due to some faults), how many replicas of R are required to make the availability of R to be at least 99%? (2)

(i) 1. (ii) 2. (iii) 3. (iv) 4.

1. c. A startup company has developed a cloud file storage system with low budget, which results in occasional network partitions (due to failures of cloud's nodes) and high network latency. The startup company wants to market its storage system as: providing two guarantees — (1) all changes to any file to be "immediately" visible to all other clients; (2) any client to access any file at any time. Justify (in one sentence) whether or not this is possible? (2)

1. d. Consider a simple checkpointing algorithm, where every process records a local checkpoint immediately after sending a message. Is the set of all latest local checkpoints recorded by all processes consistent? (2)

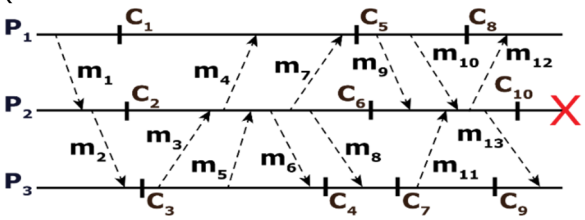
(i) Yes (ii) No

1. e. In message-logging based rollback recovery, define (in one sentence) Always-No-Orphans condition mathematically. Using this condition, define (in one sentence) orphan process. (1+1)

2. Till 2008, Facebook® has supported passive replication through its two data centers at California and Virginia; primary Replica-Manager is being maintained at California, while backup Replica-Manager is 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, can each of the following consistency models be supported in the replication of Facebook? Give reasons. (2½×4)
(a) Linearizability; (b) Sequential consistency; (c) Causal consistency; (d) FIFO consistency.

3. Consider a distributed system, which is comprised of processes P_1, P_2, … P_n, and is deployed in a reliable network, running two-phase commit protocol for committing a transaction. Explain the approaches that this protocol follows to resolve the situations arising from different cases of process-crash failures. Assume that only one process fails at a particular time. (10)

4. Consider a distributed application for a distributed system (which comprises of processes P_1, P_2 and P_3 residing in separate (but connected) nodes), as shown below. P_1, P_2 and P_3 communicate by exchanging messages, which are depicted as m_1 – m_{13} 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_1 – C_{10} in the figure), so that the system can restore back to a consistent state after recovery.



Consider a scenario for the above system, where P_2 fails, as shown in the figure. Can the system recover from this failure and restore back to a consistent state using different saved checkpoints? If yes, calculate consistent recovery lines (by listing corresponding checkpoints), and justify which of the recovery lines to adopt. If no recovery possible, give reasons. (10)

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