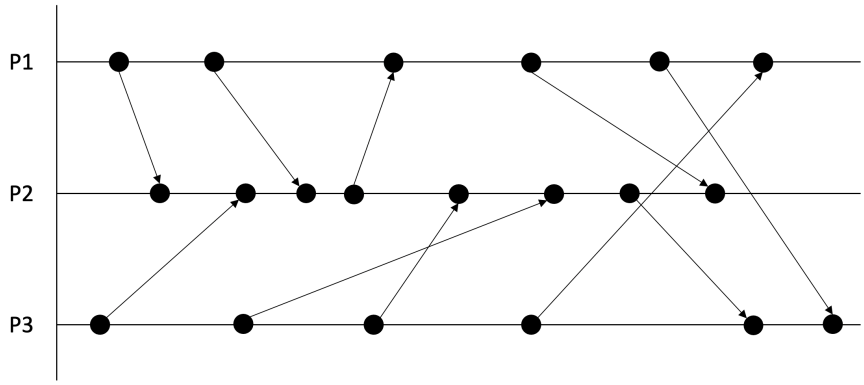
ECLT5820 Distributed and Mobile Systems

Assignment 2 (Topics 5-7)

Due – 11:59pm, 25th Oct. 2021 (Monday)

Please send a pdf file to eclt5820@cse.cuhk.edu.hk with Email title and file name "ECLT5820 Asg#2, Your name, Your student ID".

Q1 (**20 points**) Please draw the **Lamport's Timestamp** and **Vector Clock** for the following operations (assuming P1, P2 and P3 all start at 0).



Q2 (20 marks) Let us consider the common ordering requirements in distributed systems.

(1) Whether the following statements are true or false? If the statement is false, please justify your answer.
   a) Causal ordering includes FIFO ordering.
   b) FIFO ordering includes Causal ordering.
   c) Total ordering includes FIFO ordering.
   d) FIFO ordering includes Total ordering.
   e) Total ordering includes Causal ordering.
   f) Causal ordering includes total ordering.

(2) In a multi-user fighting game, the players move their figures around a common scene. The state of the game is replicated at the players' workstations and at a server which contains services controlling the game overall, such as collision detection. Updates are multicast to all replicas in the players' workstations. The figures may throw projectiles at one another and a hit debilitates the unfortunate recipient for a limited time. The game incorporates magic devices which may be picked up by a player to assist them.
   a) What type of update ordering is required for the event of the collision between the projectile and the figure, and the event of the player being debilitated (which, we may assume, is represented graphically)?

b) What type of update ordering is required for changes in the velocity of the figure and the projectile chasing it?
c) Assume that the workstation at which the projectile was launched regularly announces the projectile's coordinates, and that the workstation of the player corresponding to the figure regularly announces the figure's coordinates and announces the figure's debilitation. What type of update ordering should these announcements be processed?
d) When two players move to pick up a piece at more-or-less the same time, only one should succeed. What type of ordering should be applied to the pick-up-device operation then?

Q3 (**15 marks**) A conflict exists when two transactions access the same item, and at least one of the accesses is a write. Let transaction T_1 deposit \$100 to account Alice (A) and \$200 to account Bob (B); transaction T_2 transfer 20% of the balance from Alice to Bob. The followings are three interleaving schedules:

Schedule 1	
T_1	T_2
Read(A)	
A:=A+100	
Write(A)	
	Read(A)
	t:=A*0.2
	A:=A-t
	Write(A)
	Read(B)
	B:=B+t
	Write(B)
Read(B)	
B:=B+200	
Write(B)	

Schedule 2	
T_1	T_2
Read(A)	
A:=A+100	
Write(A)	
Read(B)	
B:=B+200	
Write(B)	
	Read(A)
	t:=A*0.2
	A:=A-t
	Write(A)
	Read(B)
	B:=B+t
	Write(B)

Schedule 3	
T_1	T_2
Read(B)	
B:=B+200	
Write(B)	
	Read(A)
	t:=A*0.2
	A:=A-t
	Write(A)
Read(A)	
A:=A+100	
Write(A)	
	Read(B)
	B:=B+t
	Write(B)

(1) Are these schedules serially equivalent interleavings? If so, what are they serially equivalent to? Please explain.

(2) Assuming transactions T_1 and T_2 will commit only after the last operation (i.e., Write(A) or Write(B) for T_1 and Write(B) for T_2). Which transaction(s) are strict transaction(s)? Identify which of the following problems is encountered in any of the three schedules (please indicate all such problems in these transactions, if any):

a) dirty reads problem
b) premature writes problem (assuming 'overlaps' are not allowed for write operations of different transactions)

Please explain your answers in detail.

Q4 (15 marks) An enhanced two-phase commit protocol has the following parts:

Step 1: The same as the first phase of the two-phase commit protocol.

Step 2: The coordinator collects the votes and makes decisions; if the decision is *No*, it aborts and informs participants that voted *Yes*; if it is *Yes*, it sends a *preCommit* request to all the participants. Participants that voted *Yes* wait for a *preCommit* or *doAbort* request. They acknowledge *preCommit* requests, and carry out *doAbort* requests.

Step 3: The coordinator collects the acknowledgments. When all are received, it *Commits* and sends *doCommit* to the 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 comparing with the two-phase commit protocol. Assume that communication does not fail.

Q5 (15 marks) Please answer the following two questions.

1) Apply two-phase locking protocol to the schedules below by adding statements like R-lock(A), W-lock(A), and unlock(A).

T_1	T_2
read(A)	
read(B)	
	read(B)
read(C)	
	read(A)
	read(C)
	write(D)
	write(A)
write(B)	
write(A)	

2) In this 2-phase locking schedule, are there any problems? If yes, explain problem in detail, and propose two ways to solve them (1) by changing the interleaving schedule (2) by changing the lock mode (but without directly changing the interleaving schedule).

Q6 (15 marks) The "transfer" transactions T and U are defined as:

T: a.withdraw(40); b.deposit(40);
U: c.withdraw(30); b.deposit(30);

Suppose that they are structured as pairs of nested transactions:

T_1: a.withdraw(40); T_2: b.deposit(40);
U_1: c.withdraw(30); U_2: b.deposit(30);

We would like to consider the recovery aspects of the nested transactions. Assume that a *withdraw* transaction will abort if the account will be overdrawn. In this case, the parent transaction will also abort. Describe serially equivalent interleavings of T_1, T_2, U_1 and U_2 with the following properties:

1) That are strict
2) That are not strict

Based on your solutions, answer to what extend does the criterion of *strictness* reduce the potential concurrency gain of nested transactions?