Database Development and Design (CPT201)

Tutorial 5: Transaction, Concurrency and Failure Recovery

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Q1

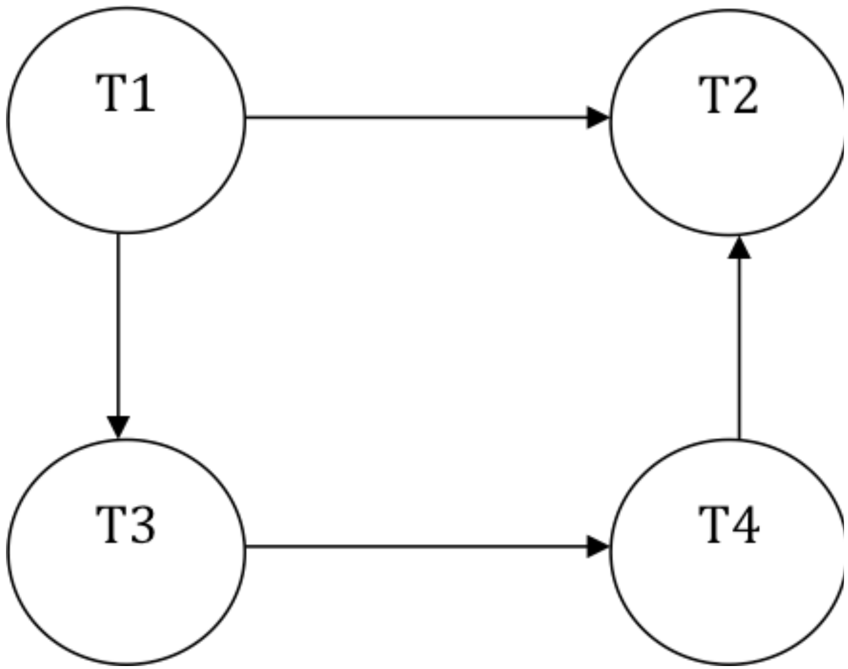
- Draw a precedence diagram for the schedule below and determine if it is conflict serialisable, and if yes, to which serial schedule it is equivalent to.
- Schedule: T1:read(X); T1:write(X); T1:read(Y); T2:read(X); T3:write(Y); T2:read(Z); T4:read(Y); T4:read(W); T4:write(W); T2:read(W);
- *Hint: list the instructions in the schedule in a table first.*

Q1 Solution

T1	T2	T3	T4
read(X)			
write(X)			
read(Y)			
	read(X)		
		write(Y)	
	read(Z)		
			read(Y)
			read(W)
			write(W)
	read(W)		

This step does not need to be shown in your answer but would help you solve the problem. This can be used for all similar questions.

Q1 Solution – cont'd



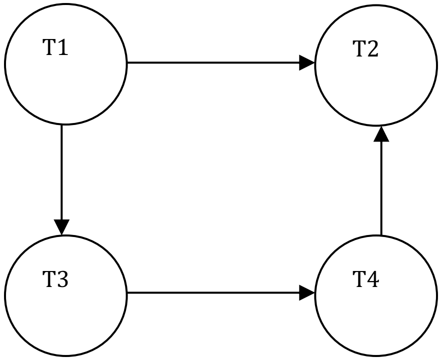
- No cycle, so it is conflict serialisable.
- Equivalent to serial schedule: <T1, T3, T4, T2>

Q2

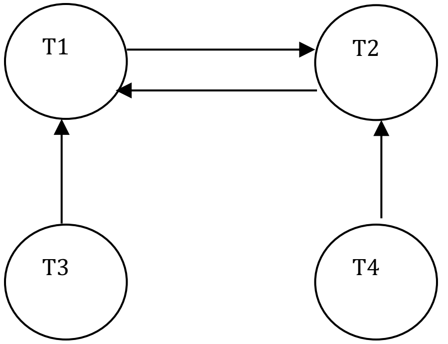
- Determine if the following two schedules are conflict serialisable by drawing the precedence graph. If so, identify the equivalent serial schedule. When drawing the precedence graph show all the edges.
  - S1: r1(X); w1(X); r1(Y); r2(X); w3(Y); r2(Z); r4(Y); r4(W); w4(W); r2(W);
  - S2: r1(X); r2(X); r1(Y); r2(Y); r3(X); r4(Y); w1(X); w2(Y);
- *Hint:*
  - *r1(X) – transaction T1 read(X)*
  - *w2(Y) - transaction T2 write(Y)*

Q2 Solution

- S1: This is a directed acycle graph. Therefore S1 is conflict serialisable and it is equivalent to a serial schedule of <T1, T3, T4, T2>.



- S2: There is a cycle in the graph. Therefore S2 is not conflict serialisable.



Q3

- Is the following schedule recoverable? Justify your answer.
- T1:write(X); T1:write(Y); T2:read(X); T2:write(Y); T2:abort; T1:write(Z); T1:commit; T3:read(Y); T3:write(Z); T3:commit.

Q3 Solution

- The above schedule is recoverable.
- Justification
  - X is written by T1 and read by T2 and T2 is aborted;
  - Y is written by T1 and read by T3 and T3 is committed after T1.

Q4

- What is the problem with the following schedule using 2PL? Justify your answer.

T1	T2
lock-X(B);	
read(B);	
B := B − 50;	
write(B);	
	lock-S(A);
	read(A);
	lock-S(B);
lock-X(A);	
read(A);	
A := A + 50;	
write(A);	
unlock(B);	
unlock(A).	
	read(B);
	display(A + B);
	unlock(A);
	unlock(B).

Q4 Solution

- The deadlock problem will arise.
- Justification
  - T2 requests the shared lock on B, however, B is locked by T1 using the exclusive lock.
  - T1 requests the exclusive lock on A, but A is locked by T2 using the shared lock.
  - So neither of the transactions can proceed.

Q5

The assignments happen within the local memory space of the transactions and the effects of these assignments are not reflected in the database until the **write** operation. If the database failure happens immediately after time=7, (1) which transactions need to be redone and which need to be undone? Justify your answer. (2) what logs need to be added?

Time	T1	T2	T3
0			start
1			read(Y)
2			Y=Y+1
3	start		
4	read(X)		
5	X=X+1		
6			write(Y)
7			commit
8		start	
9		read(X)	
10		read(Y)	
11		Y=Y+X	
12		write(Y)	
13		commit	
14	read(Y)		
15	Y=Y+X		
16	write(X)		
17	----------------------	---Checkpoint ----	-------------------
18	commit		

Hint: failure at time=7, so all operations after that are invisible.
The most recent checkpoint is not shown, only focus on what can be seen.

Q5 Solution

- (1)
  - The recovery algorithm will scan from the last checkpoint, which is not shown in the above schedule. From this partial schedule, T1 (be more precise, part of the instructions in T1) and T3 need to be redone.
  - As T2 started after the failure, so it is not relevant.
  - At the end of the redo pass, as T3 already committed before the failure so it is removed from the undo list. So this pass will produce an undo list which only contains T1.
  - In the undo pass, T1 needs to be undone.
- (2)
  - <T1 abort>

Q6

- Examine the schedule given below. There are three transactions, T1, T2, and T3. Initially, the value of X = 1 and Y = 2. The assignments happen within the local memory space of the transactions and the effects of these assignments are not reflected in the database until the **write** operation. Assume that the operations happen instantaneously, so there is no delay on the execution of an operation in the schedule.

Q6 cont'd

time	T1	T2	T3
0			start
1			read(Y)
2			Y=Y+1
3	start		
4	read(X)		
5	X=X+1		
6			write(Y)
7			commit
8		start	
9		read(X)	
10		read(Y)	
11		Y=Y+X	
12		write(Y)	
13		commit	
14	read(Y)		
15	Y=Y+X		
16	write(X)		
17	----------------------	---Checkpoint ----	-------------------
18	commit		

Q6 cont'd

- (a) What log entries would be generated by this execution up to time=17?
- (b) Assume that the undo/redo algorithm with checkpoints is used, and the database crashes just after statement 17. Assume that all the log records until this point are on disk.
  - What transactions would have to be undone?
  - What transactions would have to be redone?
  - What logs need to be added after the successful recovery?

Q6 Solution

- (a)
  - <T3 start>
  - <T1 start>
  - <T3, Y, 2, 3>
  - <T3 commit>
  - <T2 start>
  - <T2, Y, 3, 4>
  - <T2 commit>
  - <T1, X, 1, 2>
  - <checkpoint {T1}>
  - <T1 commit>

Q6 Solution cont'd

- (b)
  - T1 needs to be undone
  - No transaction needs to be redone
    - part of the instructions in T1 also need to be redone. *You don't have to mention this, but you should know it.*
  - <T1, X, 1>

    <T1 abort>