CS 411 Database Systems **Homework 4**

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1.

R1(A); R1(B); W1(B); R1(C); W1(C); W1(D); R1(E); W1(E)

Explanation:
T1 reads mobile phone specification and preorder information from A and B. It also writes a preorder request to B.

T1 reads delivery data from C and writes selected details in C

T1 generates the bill and writes to element D

T1 fetches list E. Customer bill, phone number, is added to this list and stored back to E

2. Isolation Level and Locking

2.1. T1: Repeatable Read T2: Read Committed

S1: R1(A), R2(C), R1(B), W1(C), R2(A), W2(B), R1(A), R1(B), R2(A)
S2: R2(A), R1(B), R2(C), R1(A), W1(C), R2(C), W2(B), R2(A)

S1: SLOCK1(A); R1(A); SLOCK2(C); R2(C); REL2(C); SLOCK1(B); R1(B); XLOCK1(C); W1(C); SLOCK2(A); R2(A); REL2(A); XLOCK2(B); DENIED2(B);

The lock table is as shown .

A	B	C
SLOCK1	SLOCK1	~~SLOCK2~~
SLOCK2	XLOCK2 - DENIED	XLOCK2

T2 tries acquiring exclusive lock on B , but T1 already holds a shared lock on B.And since T1 is on repeatable read isolation level, it wont release this shared lock until T1 is completed . Hence T2 is denied the lock and Schedule **S1 is not feasible under** given isolation levels

S2: SLOCK2(A); R2(A); REL2(A); SLOCK1(B); R1(B); SLOCK2(C); R2(C); REL2(C); SLOCK1(A); R1(A); XLOCK1(C); W1(C); REL1(A, B, C); SLOCK2(C); R2(C); REL2(C); XLOCK2(B); W2(B); SLOCK2(A); R2(A); REL2(A, B);

A	B	C
~~SLOCK2~~	~~SLOCK1~~	~~SLOCK2~~
~~SLOCK1~~	~~XLOCK2~~	~~XLOCK1~~
~~SLOCK2~~		~~SLOCK2~~

Schedule S**2 is feasible under** given isolation levels

2.2. T1: Repeatable Read T2: Repeatable Read

S1: *SLOCK1(A); R1(A); SLOCK2(C); R2(C); SLOCK1(B); R1(B); XLOCK1(C); DENIED1(C);*

A	B	C
SLOCK1	SLOCK1	SLOCK2
		XLOCK1 - DENIED

T1 is Denied exclusive lock on C as there already exists a shared lock on C by T2 which will be

released only when T2 completes. Hence this schedule **S1 is infeasible** under given isolation levels.

S2: *SLOCK2(A); R2(A); SLOCK1(B); R1(B); SLOCK2(C); R2(C); SLOCK1(A); R1(A); XLOCK1(C); DENIED1(C);*

A	B	C
SLOCK2	SLOCK1	SLOCK2
SLOCK1		XLOCK1 - DENIED

T1 is Denied exclusive lock on C as there already exists a shared lock on C by T2 which will be released only when T2 completes. Hence this schedule **S2 is infeasible** under given isolation levels

3.

3.1. T1: Repeatable Read; T2: Repeatable Read

S1: Q1(T2), Q2(T1), Commit(T1), Q1(T2)

<table>
<tr><th>Transaction1 T1</th><th>Transaction2 T2</th></tr>
<tr><td>START TRANSACTION</td><td>START TRANSACTION</td></tr>
<tr><td></td><td>Q1(T2)
*acquires shared lock on 2 rows
SLOCK(tempId=1)
SLOCK(tempId = 2000)

SELECT * FROM Temperatures WHERE cityName='Portland';
/reads 2 rows/

Result:<table><tr><td>tempId</td><td>temperature</td><td>cityName</td></tr><tr><td>1</td><td>50</td><td>Portland</td></tr><tr><td>2000</td><td>90</td><td>Portland</td></tr></table></td></tr>
<tr><td>Q2(T1)
*Acquires exclusive lock on new row with id =10001
XLOCK(tempId=100041)

INSERT INTO Temperatures (tempId, temperature, cityName) VALUES (10001, 60, 'Portland');</td><td></td></tr>
<tr><td>Commit(T1)
COMMIT;

*Releases exclusive lock on new row with id =10001
REL1(tempID=100041)</td><td></td></tr>
<tr><td></td><td>Q1(T2)

Acquires new shared lock on row with id 100041
SLOCK(tempId=100041)</td></tr>
</table>

	SELECT * FROM Temperatures WHERE cityName='Portland'; /reads 3 rows/ **Result:** tempId | **temperature** | **cityName** **1** | **50** | **Portland** **2000** | **90** | **Portland** **10001** | **60** | **Portland** **and this new row was added by T1 , hence now T2 sees 2 results instead of 1 , thus leading to phantom reads.** **REL(tempId =2 , tempId=2000, tempId=100041)**

We can see phantom reads in Transaction 2 as the first select query results in 2 row s but later the same query gives 3 rows as output. This happens because transaction T1 inserts a new row in between. Hence under given isolation settings, we can see phantom reads

3.2.

S2: Q1(T2), Q2(T1), Q1(T2), Abort(T1)

T1: Read Committed; T2: Read Uncommitted.

Transaction1 T1	Transaction2 T2
START TRANSACTION	START TRANSACTION
	***acquires shared lock on 2 rows** **SLOCK(tempId=1)** **SLOCK(tempId = 2000)** **SELECT * FROM Temperatures WHERE cityName='Portland';** /reads 2 rows/ **Result:** tempId | **temperature** | **cityName** **1** | **50** | **Portland** **2000** | **90** | **Portland**
***Acquires exclusive lock on new row with id =10001** **XLOCK(tempId=100041)**	

<table>
<tr><td>INSERT INTO Temperatures (tempId, temperature, cityName) VALUES (10001, 60, ‘Portland’);</td><td></td></tr>
<tr><td></td><td>Acquires new shared lock on row with id 100041
SLOCK(tempId=100041)

SELECT * FROM Temperatures WHERE cityName=’Portland’;
/reads 3 rows/

Result:<table><tr><td>tempId</td><td>temperature</td><td>cityName</td></tr><tr><td>1</td><td>50</td><td>Portland</td></tr><tr><td>2000</td><td>90</td><td>Portland</td></tr><tr><td>10001</td><td>60</td><td>Portland</td></tr></table>
and this new row was added by T1. Even though this change is not commit, but T2 has read uncommitted setting hence now T2 sees 3 results instead of 2 , thus leading to dirty reads</td></tr>
<tr><td>ABORT
REL(tempId = 100041)</td><td></td></tr>
<tr><td></td><td>REL(tempId =2 , tempId=2000, tempId=100041)</td></tr>
</table>

The transaction T2 sees dirty read problem. Initially, T2 sees 2 rows based on cityName=Portland and in the same time T! inserts a new row with same value. NowT2 runs query again to see 3 rows as it can read uncommitted data based on its isolation level of Read uncommitted. This is what is called dirty read where transaction reads a value written by another transaction that has not yet been committed

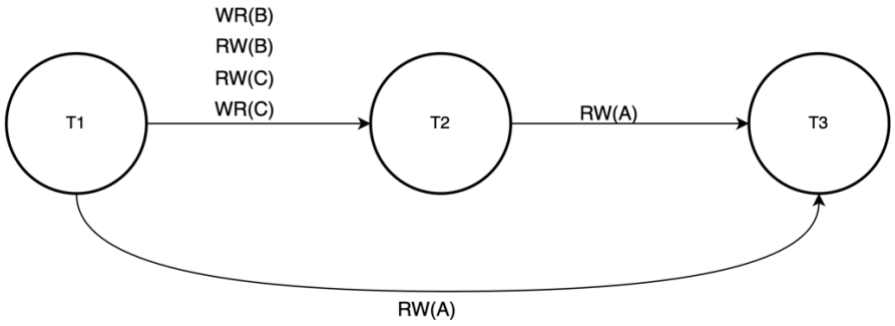
4.

4.1. S1: R1(A); R1(B); W1(B); R2(B); W2(B); R1(C); W1(C); R2(C); W2(C); R2(A); R3(A); W3(A);

Solution: The schedule can be written in tabular form as

T1	T2	T3
R(A)		
R(B)		
W(B)		
	R(B)	
	W(B)	
R(C)		
W(C)		
	R(C)	
	W(C)	
	R(A)	
		R(A)
		W(A)

The precedence graph is as shown below. Since the graph has no cycles, the schedule is conflict-serializable



The equivalent Serial schedule is

R1(A); R1(B); W1(B); R2(B); W2(B); R1(C); W1(C); R2(C); W2(C); R2(A); R3(A); W3(A);

R1(A); R1(B); W1(B); R2(B); R1(C);W2(B); W1(C); R2(C); W2(C); R2(A); R3(A); W3(A);

R1(A); R1(B); W1(B); R1(C); R2(B);W2(B); W1(C); R2(C); W2(C); R2(A); R3(A); W3(A);

R1(A); R1(B); W1(B); R1(C); R2(B);W1(C); W2(B); R2(C); W2(C); R2(A); R3(A); W3(A);

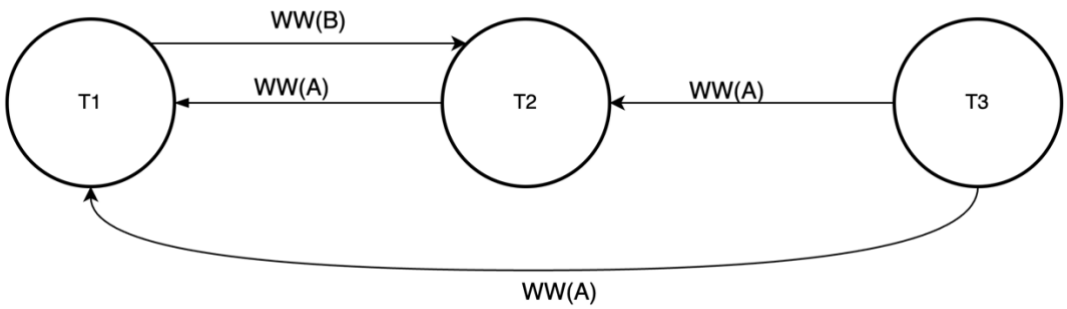
Final Serial Schedule

R1(A); R1(B); W1(B); R1(C); W1(C);R2(B); W2(B); R2(C); W2(C); R2(A); R3(A); W3(A);

T1	T2	T3
R(A)		
R(B)		
W(B)		
R(C)		
W(C)		
	R(B)	
	W(B)	
	R(C)	
	W(C)	
	R(A)	
		R(A)
		W(A)

4.2. S2: R3(C); W1(B); W2(B); W3(A); R1(C); W2(A); W1(A);

T1	T2	T3
		R(C)
W(B)		
	W(B)	
		W(A)
R(C)		
	W(A)	
W(A)		



There is a cycle in the precedence graph and hence the schedule **S2 is not conflict-serializable.**

The transactions that make the schedule not conflict-serializable are **T1 and T2 .**
The actions involved are
T1 →T2 : W1(B);W2(B); and
T2 →T1: W2(A);W1(A);

5. 2PL locking

5.1.

S1: W3(C), W1(A), R2(B), W3(B), R2(B), W1(B)
S2: W1(C); W3(B); R3(B); W2(A); R1(A); R3(A); R2(A); R2(C); R2(B)
S3: R1(A); R3(B); R2(C); R1(B); R3(C); W1(A); R1(A); R3(B); W2(C)

S1: XLOCK3(C); W3(C); XLOCK1(A); W1(A); SLOCK2(B); R2(B); XLOCK 3(B):DENIED3(B)

T1	T2	T3
		XLOCK3(C)
		W3(C)
XLOCK1(A)		
W1(A)		
	SLOCK2(B)	
	R2(B)	
		XLOCK3(B) <Denied, Wait>

Since transaction 3 is denied exclusive lock for B as T2 is holding shared lock on b**. Schedule S1 cannot arise from 2PL**

S2: W1(C); W3(B); R3(B); W2(A); R1(A); R3(A); R2(A); R2(C); R2(B)

S2: XLOCK1(C); W1(C); XLOCK3(B); W3(B); R3(B); XLOCK2(A); W2(A); SLOCK1(A); DENIED1(A);

T1	T2	T3
XLOCK1(C)		
W1(C)		
		XLOCK3(B)
		W3(B)
		R3(B)
	XLOCK2(A)	
	W2(A)	
SLOCK1(A) <Denied, Wait>		

Schedule S2 cannot arise from 2PL scheduler

S3: R1(A); R3(B); R2(C); R1(B); R3(C); W1(A); R1(A); R3(B); W2(C)

S3: SLOCK1(A); R1(A); SLOCK3(B); R3(B); SLOCK2(C); R2(C); SLOCK1(B); R1(B); SLOCK3(C); R3(C); REL3(C); XLOCK1(A); W1(A); REL1(B); SLOCK1(A); R1(A); COMMIT1(A); REL1(A); R3(B); COMMIT(T3); REL3(B); XLOCK2(C); W2(C); COMMIT(T3); REL2(C)

Assumption: In case we need to release some locks and downgrade others, release locks FIRST, then downgrade the others.

T1	T2	T3
SLOCK1(A)		
R1(A)		
		SLOCK3(B)
		R3(B)
	SLOCK2(C)	
	R2(C)	
SLOCK1(B)		
R1(B)		
		SLOCK3(C)
		R3(C)
		REL3(C)
XLOCK1(A)		
W1(A)		
REL1(B)		
SLOCK1(A)		
R1(A)		
COMMIT(T1)		
REL1(A)		
		R3(B)
		COMMIT(T3)
		REL3(B)
	XLOCK2(C)	
	W2(C)	
	COMMIT(T2)	
	REL2(C)	

The Schedule S3 can be produced by a Two-Phase Lock (2PL) scheduler.

5.2.

S1: W3(C), W1(A), R2(B), W3(B), R2(B), W1(B)

XLOCK3(C); W3(C); XLOCK1(A); W1(A); SLOCK2(B); R2(B); XLOCK3(B); DENIED3(B)

S1 is not feasible using strict 2PL . We can enforce it to obtain following schedule

Enforcing String 2PL:-

S1: XLOCK3(C); W3(C); XLOCK1(A); W1(A); SLOCK2(B); R2(B); XLOCK3(B); WAIT3(B); R2(B); COMMIT T2; REL2(B); XLOCK3(B); W3(B); COMMIT T3; REL3(B, C); XLOCK1(B); W1(B); REL1(A,B); COMMIT T1;

T1	T2	T3
		XLOCK3(C)
		W3(C)
XLOCK1(A)		
W1(A)		
	SLOCK2(B)	
	R2(B)	
		XLOCK3(B) <Denied, Wait>
	R2(B)	
	COMMIT;	
	REL2(B)	
		XLOCK3(B)
		W3(B)
		COMMIT
		REL3(B, C)
XLOCK1(B)		
W1(B)		
COMMIT;		
REL1(A, B)		

S2: W1(C); W3(B); R3(B); W2(A); R1(A); R3(A); R2(A); R2(C); R2(B)

XLOCK1(C); W1(C); XLOCK3(B); W3(B); R3(B); XLOCK2(A); W2(A); SLOCK1(A); DENIED1(A);

S2 is not feasible using strict 2 PL.

Enforcing Strict 2PL on S2: -

S2: XLOCK1(C); W1(C); XLOCK3(B); W3(B); R3(B); XLOCK2(A); W2(A); SLOCK1(A); WAIT1(A); SLOCK3(A); WAIT3(A); R2(A); SLOCK2(C); WAIT2(C) ;

T1	T2	T3
XLOCK1(C)		
W1(C)		
		XLOCK3(B)
		W3(B)
		R3(B)
	XLOCK2(A)	
	W2(A)	
SLOCK1(A) <Denied, Wait>		
		SLOCK3(A)< WAIT>
	R2(A)	
	SLOCK2(C)< WAIT>	

T1 is waiting for Shared lock A. It can be obtained only when T2 finishes.
T2 is waiting on Shared lock C, which can be obtained when T1 completes.
Hence there is a deadlock

S3: R1(A); R3(B); R2(C); R1(B); R3(C); W1(A); R1(A); R3(B); W2(C)

S3: SOCK1(A); R1(A); SLOCK3(B); R3(B); SLOCK2(C); R2(C); SLOCK1(B); R1(B); SLOCK3(C); R3(C); XLOCK1(A); W1(A); R1(A); COMMIT T1; REL1(A, B); R3(B); COMMIT T3; REL3(B,C); XLOCK2(C); W2(C); COMMIT T2; REL2(C);

T1	T2	T3
SLOCK1(A)		
R1(A)		
		SLOCK3(B)

		R3(B)
	SLOCK2(C)	
	R2(C)	
SLOCK1(B)		
R1(B)		
		SLOCK3(C)
		R3(C)
XLOCK1(A)		
W1(A)		
R1(A)		
COMMIT(T1)		
REL1(A, B)		
		R3(B)
		COMMIT(T3)
		REL3(B, C)
	XLOCK2(C)	
	W2(C)	
	COMMIT(T2)	
	REL2(C)	

Hence the **Schedule S3 can be produced by a Strict Two-Phase Lock (2PL)** scheduler.