COMP9311 24T3: Assignment 2

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Question 1 (12 marks)

Consider a relation R (A, B, C, D, E, G, H, I, J) and its FD set $F = \{AD \rightarrow B, BD \rightarrow G, BE \rightarrow I, AE \rightarrow DI, AI \rightarrow E, AEI \rightarrow C\}$.

Regarding the following questions, please give your answers and brief justifications.

(1) Check if $AB \rightarrow G$. (1 mark)

Knowing that, AD → B, BD → G since we can't get AB → D then AB → G does not hold.

(2) Find all the candidate keys for R. (2 mark)

As we know, $AD \rightarrow B, BD \rightarrow G, BE \rightarrow I, AE \rightarrow DI, AI \rightarrow E, AEI \rightarrow C$

Let X: {A, E, J, H}

{A, E, J, H} + = {A, B, C, D, E, G, H, I, J}

Let X: {A, I, J, H}

{A, I, J, H} + = {A, B, C, D, E, G, H, I, J}

therefore, we can get AEJH, AIJH are the candidate keys for the relation R.

(3) Determine the highest normal form of R with respect to F. (2 marks)

Since $AD \rightarrow B, BD \rightarrow G, BE \rightarrow I, AEI \rightarrow C$ we can know that relation R isn't in 2NF

Therefore, 1NF is the highest normal form of R.

(4) Find a minimal cover Fm for F. (2 marks)

Step 1: Reduce right side.

Fm = {AD → B, BD → G, BE → I, AE → D, AE → I, AI → E, AEI → C}

Step 2: Reduce left side.

Fm = {AD → B, BD → G, BE → I, AE → D, AE → I, AI → E, AE → C}

Step 3: Remove redundant FDs.

Fm = {AD → B, BD → G, BE → I, AE → D, AE → I, AI → E, AE → C}

Therefore, the minimal cover Fm = {AD → B, BD → G, BE → I, AE → D, AE → I, AI → E, AE → C}

(5) Regarding F, does the decomposition R1 = {ABCDJ}, R2 = {BDGI}, R3 = {BCEH} of R satisfy the lossless join property? (2 marks)

	A	B	C	D	E	G	H	I	J
R_1	a	a	a	a	b	~~b~~ a	b	b	a
R_2	b	a	b	a	b	a	b	a	b
R_3	b	a	a	b	a	b	a	b	b

Since there is row that all take the value a, then the decomposition R1, R2, R3 doesn't satisfy the lossless join property.

(6) Provide a step-by-step lossless decomposition of R into BCNF normal form. (3marks)

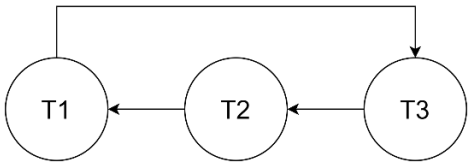
Consider AD → B, in the minimal cover is not a super key. Decompose R into R1 and R2.
R1= {A, D, B} with key: {AD}
R2= {A, D, C, E, G, H, I, J} with AE → DI violates BCNF since AE is not super key.
R11= {A, E, D, I} with key: {AE}
R12= {A, E, C, G, H, J}

Question 2 (8 marks)

Consider the schedule below. Here, R(*) and W(*) stand for 'Read' and 'Write', respectively. T1, T2 and T3 represent 3 transactions, and t1, t2,…, t12 represents different time slots.
Note: Each transaction begins at the time slot of its first operation and commits right after its last operation (same time slot).

(1)Is the schedule serializable? If it is not serializable, draw a precedence graph; otherwise, provide an equivalent serial schedule. (2 marks)

It is not serializable.



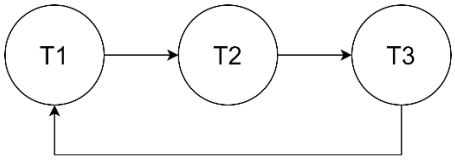
(2) Use the Two-Phase Locking protocol to add appropriate locks/unlocks for each of the transactions. (3 marks)

T1	T2	T3
read_lock(x);	read_lock(y);	read_lock(z);
R(x)	R(y)	R(z)
read_lock(y);	read_lock(z);	read_lock(x);
R(y)	R(z)	R(x)
write_lock(x);	write_lock(y);	write_lock(z);
W(x)	W(y)	W(z)
write_lock(y);	write_lock(z);	write_lock(x);
W(y)	W(z)	W(x)
unlock(x);	unlock(y);	unlock(x);
unlock(y);	unlock(z);	unlock(z);

(3) Based on the locks/unlocks you added in q(2), if the transactions attempt to follow the schedule in the table, what will happen? Please justify your answer using the method learned from the lecture. (3 marks)

There will be an issue of deadlock.

Create a wait-for graph for currently active transactions:



Question 3 (6 marks)

Consider the following page request sequence:

P1, P2, P1, P4, P3, P7, P2, P1, P4, P5, P8, P6, P8, P2, P8.

Assume there are 3 buffers in the buffer pool.

(1) Sketch the process of how blocks are replaced in the Least Recently Used (LRU) policy, and calculate the cache hit rate. (2 marks)

Q1	Q2	Q3
P2	P1	P4
P1	P4	P3
P4	P3	P7
P3	P7	P2
P7	P2	P1
P2	P1	P4
P1	P4	P5
P4	P5	P8
P5	P8	P6
P5	P6	P8
P6	P8	P2

Hit rate= $\frac{3}{15}$ =20%

(2) Sketch the process of how blocks are replaced in the Most Recently Used (MRU) policy, and calculate the cache hit rate. (2 marks)

Q1	Q2	Q3
P1	P2	P4
P1	P2	P3
P1	P2	P7
P1	P2	P7
P4	P2	P7
P5	P2	P7
P8	P2	P7
P6	P2	P7
P8	P2	P7
P8	P2	P7
P8	P2	P7

Hit rate= $\frac{5}{15}$ =33%

(3) Sketch the process of how blocks are replaced in the First In First Out (FIFO) policy, and calculate the cache hit rate. (2 marks)

Q1	Q2	Q3
P1	P2	P4
P3	P2	P4
P3	P7	P4
P3	P7	P2
P1	P7	P2
P1	P4	P2
P1	P4	P5
P8	P4	P5
P8	P6	P5
P8	P6	P2

Hit rate= $\frac{3}{15}$ =20%