**Assignment 2**

**Question 1**

Consider a relation 𝑅(𝐴, 𝐵, 𝐶,𝐷, 𝐸, 𝐺, 𝐻,𝐼,𝐽) and its FD set 𝐹 = {𝐴B → 𝐷E, 𝐶 → 𝐺H, 𝐸 → 𝐵CD,𝐷 → 𝐶I, 𝐻 → 𝐺, 𝐸H → 𝐼}.

1) Check if 𝐸 → 𝐺 ∈ F+. Justify your answer. (2 mark)

∵ 𝐸 → 𝐵CD ∴ E+ = {BCDE}

∵ 𝐶 → 𝐺H ∴ E+ = {BCDEGH}

∵ G belongs to E+ = {BCDEGH} ∴E → G is in F+.

2) List all the candidate keys for 𝑅. (2 marks)

A and J need to be present in every candidate key, because they cannot be derived from any of the FD provided.

AJ+ = {AJ}

∵ ABJ+ = {ABDECGHIJ} = R, AEJ+ = {AEJBCDGHI} = R

∴ ABJ and AEJ are candidate keys

3) How many super keys can be found for R? Compute the total number of super keys and

list 5 of them. (2 marks)

∵ Any superset of candidate key is a super key and there are 9 attributes in R

∴ number of super keys can be found for R = 2(9-3) +2(9-3)-2(9-4) = 96

5 super keys could be: ABJ, AEJ, ABCJ, ABDJ, ABGJ

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

F1 = {𝐴B → 𝐷, 𝐴B → E, 𝐶 → 𝐺, 𝐶 → H, 𝐸 → 𝐵, 𝐸 → C, 𝐸 → D, 𝐷 → 𝐶, 𝐷 → I, 𝐻 → 𝐺, 𝐸H → 𝐼}

∵ A+ = {A} and B+ = {B} and E+ ={BCDGHI}andH+ ={HG}

∴ F2 = {𝐴B → 𝐷, 𝐴B → E, 𝐶 → 𝐺, 𝐶 → H, 𝐸 → 𝐵, 𝐸 → C, 𝐸 → D, 𝐷 → 𝐶, 𝐷 → I, 𝐻 → 𝐺, 𝐸 → 𝐼}

∴ Fm = {𝐴B → E, 𝐶 → H, 𝐸 → 𝐵, 𝐸 → D, 𝐷 → 𝐶, 𝐷 → I, 𝐻 → 𝐺}

5) Determine the highest normal form of 𝑅 with respect to 𝐹. Justify your answer. (2 marks)

∵ ABJ, AEJ are candidate keys

∴ Non-prime attribute D is functionally dependent on E, which is not a candidate key.

∴ R with respect to F is in 1NF

6) Regarding F, is the decomposition R1 = {ABCDE}, R2 = {CGH}, R3 = {EIJ} of R

dependency-preserving? Please justify your answer. (2 marks)

∵ R1 = {ABCDE} ∴ FR1 = {𝐴B → 𝐷E, 𝐸 → 𝐵CD, D→C}

∵ R2 = {CGH} ∴ FR2 = {𝐶 → 𝐺H, 𝐻 → 𝐺}

∵ R3 = {EIJ} ∴ FR3 = {}

∵ 𝐷 → I is lost ∴ it is not dependency-preserving

7) Regarding F, is the decomposition R1 = {ABCDE}, R2 = {CGH}, R3 = {EIJ} of 𝑅

lossless-join? Please justify your answer. (2 marks)

A B C D E G H I J

R1 a a a a a

R2 a a a

R3 a a a

∵ 𝐸 → 𝐵CD

A B C D E G H I J

R1 a a a a a

R2 a a a

R3 a a a a a a

∵ 𝐶 → 𝐺H

A B C D E G H I J

R1 a a a a a a a

R2 a a a

R3 a a a a a a a a

∵ 𝐷 → 𝐶I

A B C D E G H I J

R1 a a a a a a a a

R2 a a a

R3 a a a a a a a a

∵ There is not any row with all a

∴ It is not loss-less join.

8) Decompose it into a collection of BCNF relations if it is not in BCNF. Make sure your

decomposition is lossless-join and briefly justify your answers. (2 marks)

∵ minimal cover Fm = {𝐴B → E, 𝐶 → H, 𝐸 → 𝐵, 𝐸 → D, 𝐷 → 𝐶, 𝐷 → I, 𝐻 → 𝐺} and the left-hand side of FD H→G is not a super key

∴ R1 = {H, G} and R2 = {A, B, C, D, E, H, I, J}

∵ The left-hand side of D→I is not a super key

∴ R21 = {D, I} and R22 = {A, B, C, D, E, H, J}

∵ The left-hand side of C→H is not a super key

∴ R221 = {C, H} and R222 = {A, B, C, D, E, J}

∵ The left-hand side of D→C is not a super key

∴ R2221 = {C, D} and R2222 = {A, B, D, E, J}

∵ The left-hand side of E→B and E→D is not a super key

∴ R22221 = {E, D, B} and R22222 = {A, E, J}

∴ One of the possible lossless-join decomposition to BCNF is: R1 = {H, G}, R21 = {D, I}, R221 = {C, H}, R2221 = {C, D}, R22221 = {E, D, B} and R22222 = {A, E, J}

**Question 2**

1) Assume a checkpoint is made between t4 and t5, what should be done to the four transactions when the crash happens between t6 and t7. (2 marks)

Undo T1, T2, T4 because they are not committed while crash. Since T3 didn’t start or commit while the crash happened, noting will be done to T3.

2) Is the transaction schedule conflict serializable? Give the precedence graph to justify your answer. (2 marks)

Not conflict serializable

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Description automatically generated3) Give a serial schedule of these four transactions. (2 marks)

In the serial schedule, one transaction is executed completely before starting another transaction.

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4) Construct a schedule (which is different from above) of these four transactions which

causes deadlock when using two-phase locking protocol. If no such schedule exists, explain

why. (2 marks)

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**Question 3**

1) There are currently 11 records in this tree. How many additional records could be added to this tree without changing its height (give the maximum possible number)? (3 marks)

The maximum number of records can be stored is bh – bh-1

∵ According to the graph of the tree, each node can have 4 children and 3 keys.

∴ The maximum possible number of records without change its height = 43 -42= 48

∵ There are currently 11 records

∴ The number of additional records without change its height = 48-11 = 37

2) Show the B+ tree after deleting the data entry with key 49 from the original tree. (3 marks)

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