Assignment 2

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Question 1

Consider a relation $R(A,B,C,D,E,G,H,I,J,K)$ and its FD set $F = \{A \rightarrow BC, E \rightarrow AD, BD \rightarrow E, CE \rightarrow DH, H \rightarrow G, EI \rightarrow J\}$.

1) Check if $C \rightarrow J \in F^+$.

   $C \rightarrow J \in F^+$ iff. $J \subseteq C^+$.

   $C^+ = \{C\}$, $J \notin C^+$

   So $C \rightarrow J \notin F^+$

2) Find a minimal cover F for F.

   Step 1:

   $F' = \{A \rightarrow B, A \rightarrow C, E \rightarrow A, E \rightarrow D, BD \rightarrow E, CE \rightarrow D, CE \rightarrow H, H \rightarrow G, EI \rightarrow J\}$

   Step 2:

   $BD \rightarrow E$: $B^+ = \{B\}$; thus $B \rightarrow E$ is not inferred by F'.

   $D^+ = \{D\}$; thus $D \rightarrow E$ is not inferred by F'.

   Hence, $BD \rightarrow E$ cannot be replaced.

   $CE \rightarrow D$: $C^+ = \{C\}$; thus $C \rightarrow D$ is not inferred by F'.

   $E^+ = \{D, E\}$; thus $E \rightarrow D$ is inferred by F'.

   Hence, $CE \rightarrow D$ can be replaced by $E \rightarrow D$.

   $CE \rightarrow H$: $C^+ = \{C\}$; thus $C \rightarrow H$ is not inferred by F'.

   $E^+ = \{A, B, C, D, E, H, G\}$; thus $E \rightarrow H$ is inferred by F'.

   Hence, $CE \rightarrow H$ can be replaced by $E \rightarrow H$

   $EI \rightarrow J$: $E^+ = \{D, E\}$; thus $E \rightarrow J$ is not inferred by F'.

   $I^+ = \{I\}$; thus $I \rightarrow J$ is not inferred by F'.

Hence, $EI \rightarrow J$ cannot be replaced.

$F'' = \{A \rightarrow B, A \rightarrow C, E \rightarrow A, E \rightarrow D, BD \rightarrow E, E \rightarrow H, H \rightarrow G, EI \rightarrow J\}$

Step 3:

$A^+|_{F''-\{A\rightarrow B\}} = \{A, C\}$; thus $A \rightarrow B$ is not inferred by $F''-\{A \rightarrow B\}$.That is, $A \rightarrow B$ is not redundant.

$A^+|_{F''-\{A\rightarrow C\}} = \{A, B\}$; thus $A \rightarrow C$ is not inferred by $F''-\{A \rightarrow C\}$.That is, $A \rightarrow C$ is not redundant.

$E^+|_{F''-\{E\rightarrow A\}} = \{E, D\}$; thus $E \rightarrow A$ is not inferred by $F''-\{E \rightarrow A\}$.That is, $E \rightarrow A$ is not redundant.

$E^+|_{F''-\{E\rightarrow D\}} = \{A, B, C, E, H, G\}$; thus $E \rightarrow D$ is not inferred by $F''-\{E \rightarrow D\}$.That is, $E \rightarrow D$ is not redundant.

$BD^+|_{F''-\{BD\rightarrow E\}} = \{B, D\}$; thus $BD \rightarrow E$ is not inferred by $F''-\{BD \rightarrow E\}$.That is, $BD \rightarrow E$ is not redundant.

$E^+|_{F''-\{E\rightarrow H\}} = \{A, B, C, D, E\}$; thus $CE \rightarrow H$ is not inferred by $F''-\{CE \rightarrow H\}$.That is, $CE \rightarrow H$ is not redundant.

$H^+|_{F''-\{H\rightarrow G\}} = \{H\}$; thus $H \rightarrow G$ is not inferred by $F''-\{H \rightarrow G\}$.That is, $H \rightarrow G$ is not redundant.

$EI^+|_{F''-\{EI\rightarrow J\}} = \{A, B, C, D, E, H, G, I\}$; thus $EI \rightarrow J$ is not inferred by $F''-\{EI \rightarrow J\}$.That is, $EI \rightarrow J$ is not redundant.

$F'' = \{A \rightarrow B, A \rightarrow C, E \rightarrow A, E \rightarrow D, BD \rightarrow E, E \rightarrow H, H \rightarrow G, EI \rightarrow J\}$

Thus,

$\boldsymbol{F_{min} = \{A \rightarrow B, A \rightarrow C, E \rightarrow A, E \rightarrow D, BD \rightarrow E, E \rightarrow H, H \rightarrow G, EI \rightarrow J\}}$

3) Regarding F, is the decomposition $R1 = \{ABCDE\}$, $R2 = \{EGH\}$, $R3 = \{EIJK\}$ of R lossless-join? Please justify your answer.

It is lossless-join.

Step 1:

Create a matrix.

	A	B	C	D	E	G	H	I	J	K
ABCDE	a	a	a	a	a	b	b	b	b	b
EGH	b	b	b	b	a	a	a	b	b	b
EIJK	b	b	b	b	a	b	b	a	a	a

Step 2:

	A	B	C	D	E	G	H	I	J	K
ABCDE	a	a	a	a	a	b	b	b	b	b
EGH	a	b	b	a	a	a	a	b	b	b
EIJK	a	b	b	a	a	b	b	a	a	a

	A	B	C	D	E	G	H	I	J	K
ABCDE	a	a	a	a	a	a	a	b	b	b
EGH	a	a	a	a	a	a	a	b	b	b
EIJK	a	a	a	a	a	a	a	a	a	a

Row EIJK(R3) is made up entirely of "a" symbols. So it is a lossless-join.

4) List at least 5 super-keys for R.

$X = \{A, D, E, G, H, I, J, K\}$.

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$X = \{A, B, C, E, G, H, I, J, K\}$.

$X = \{A, B, C, D, E, H, I, J, K\}$.

5) Is it possible to decompose R into a collection of BCNF relations and ensure the decomposition is dependency-preserving and lossless-join? Please justify your answers.

It is not possible to decompose R into a collection of BCNF relations and ensure the decomposition is dependency-preserving and lossless-join.

Step 1:

From $A \rightarrow BC$, we decompose R into $R1(A, D, E, G, H, I, J, K)$ and $R2(A, B, C)$.

$R1(A, D, E, G, H, I, J, K)$, $Key=\{A, E, H, I\}$

2 nontrivial FDs in F+ violates BCNF: $\{A, E, H, I\} \rightarrow D$, $\{A, E, H, I\} \rightarrow K$

$R2(A, B, C)$, $Key=\{A\}$

Only one nontrivial FD in F+ : $A \rightarrow BC$

Step 2:

R1 is not in BCNF so we must decompose it further into $R11(E, G, H, I, J, K)$ and $R12(A, D, E)$ from $E \rightarrow AD$.

$R11(E, G, H, I, J, K)$, *Key = {E, H, I}*

1 nontrivial FDs in F+ violates BCNF: $\{E, H, I\} \rightarrow K$

$R12(A, D, E)$, *Key = {D, E}*

Only one nontrivial FD in F+ *:* $DE \rightarrow A$

Step 3:

R11 is not in BCNF so we must decompose it further into $R111(E, H, I, J, K)$ and $R112(H, G)$ from $H \rightarrow G$.

$R111(E, H, I, J, K)$, *Key = {E, I}*

2 nontrivial FDs in F+ violates BCNF: $\{E, I\} \rightarrow K$, $\{E, I\} \rightarrow H$

$R112(H, G)$, *Key = {H}*

Only one nontrivial FD in F+ *:* $H \rightarrow G$

Step 4:

R111 is not in BCNF so we must decompose it further into $R1111(E, H, I, K)$ and $R1112(E, I, J)$ from $EI \rightarrow J$.

$R1111(E, H, I, K)$, could be decomposed into two nontrivial without violates BCNF.

$R1112(E, I, J)$, *Key = {E, I}*

Only one nontrivial FD in F+ *:* $EI \rightarrow J$

Finally:

This is in BCNF and the decomposition is lossless but not dependency preserving (the FDs $BD \rightarrow E$ and $CE \rightarrow DH$) has been lost.

Actually, even though we change the decomposition order, there is no possibility to get a collection of BCNF relations and ensure the decomposition is dependency-preserving and lossless-join.

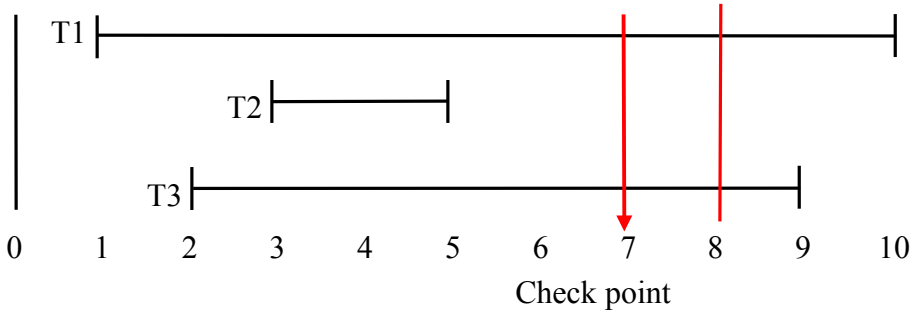
The reason is there are $BD \rightarrow E$, $E \rightarrow AD$ and $CE \rightarrow DH$ in *F*. It means we will definitely lose one of these dependency in the process of doing lossless decomposition into BCNF from others FD.

Thus, it is not possible to decompose R into a collection of BCNF relations and ensure the decomposition is dependency-preserving and lossless-join.

Question 2

Following is the schedule A for transactions T_1, T_2, and T_3: Schedule A

1) Assume that the system crashes at time 8, what should be done to recover the system?



As system crashes at time 8, T1 and T3 is not committed yet, as well as T2 is already committed.

So, to recover the system, operations below should be done.

T1: UNDO

T2: REDO

T3: UNDO

2) Assume a checkpoint is made at time 7, what should be done to the three transactions when the crash happens at time 8?

As there is a check point at time 7, T2 is already committed and T1, T3 are still in processing. So, to recover the system, there is no need to UNDO or REDO T2. However, T1 and T3 need to be UNDO.

T1: UNDO

T3: UNDO

Question 3

Give and justify the answers regarding the following problems:

1) Construct a scenario that First in First Out (FIFO) buffer replacement policy is better than Most Recently Used (MRU) buffer replacement policy.

   Data pages: P1, P2, P3

   Queries: Q1: read P1, P2;

   Q2: read P2;

   Q3: read P3;

   Q4: read P2;

   Buffer: 2 pages

Q1	P1 Q1	P2 Q1			
Q2	P1 Q1	P2 Q2			
Q3	P3 Q3	P2 Q2	FIFO	P1 Q1	P3 Q3	MRU
Q4	P3 Q3	P2 Q4	FIFO	P1 Q1	P2 Q4	MRU

   In this case, when doing query 4, MRU need to get out P3 and get in P2 while FIFO do not need to. So FIFO performance better than MRU.

2) Construct a scenario that First in First Out (FIFO) buffer replacement policy is better than Least Recently Used (LRU) buffer replacement policy.

   Data pages: P1, P2, P3

   Queries: Q1: read P1, P2;

   Q2: read P1;

   Q3: read P3;

   Q4: read P2;

   Buffer: 2 pages

Q1	P1 Q1	P2 Q1

Q2	P1 Q2	P2 Q1			
Q3	P3 Q3	P2 Q1	FIFO	P1 Q2	P3 Q3	MRU
Q4	P3 Q3	P2 Q4	FIFO	P2 Q4	P3 Q3	MRU

In this case, when doing query 4, LRU need to get out P1 and get in P2 while FIFO do not need to. So FIFO performance better than LRU.