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COMP9311

Assignment 2

Question 1 (8 marks)

Consider a relation $R(A,B,C,D,E,G,H,I,J)$ and its FD set
$F=\{AB\rightarrow CE,\ D\rightarrow GH,\ E\rightarrow BCD, C\rightarrow DI,\ H\rightarrow G,\ EH\rightarrow I\}$.

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

$C\nrightarrow J$
Since there are no incoming edges into J.

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

AEJ, ABJ

3) Find a minimal cover F_m for F. (2 marks)
Ans.

$AB\rightarrow CE$,
$D\rightarrow GH$,
$E\rightarrow BCD$,
$C\rightarrow DI$,
$H\rightarrow G$,
$EH\rightarrow I$

Gets reduced to:

AB→E
D→H
E→BC
C→DI
H→G

4) Decompose into a set of 3NF relations if it is not in 3NF. Make sure your decomposition is dependency-preserving and lossless-join. Justify your answers. (3 marks)
Ans.

Candidate Keys are : AEJ and ABJ
Prime Attributes are : A, B, E, J
Non-Prime Attributes : C, D, G, H, I

For 3NF, it should be in 2NF and there should be no transitive dependencies.
1 relation will be made for both the candidate keys and rest for all FDs.

3NF:

$R_1\{ABJ\}$
$R_2\{ABE\}$
$R_3\{DH\}$
$R_4\{EBC\}$
$R_5\{CDI\}$
$R_6\{HG\}$

It is dependency preserving because all FDs : $AB \rightarrow E$, $D \rightarrow H$, $E \rightarrow BC$, $C \rightarrow DI$, $H \rightarrow G$ can be found using these relations:

$R_1 = \{ABJ\}$
No FDs for R_1

$R_2 = \{ABE\}$
FDs for R_2
$AB \rightarrow E$

$R_3 = \{DH\}$
FDs for R_3
$D \rightarrow H$

$R_4 = \{EBC\}$
FDs for R_4
$E \rightarrow BC$

$R_5 = \{CDI\}$
FDs for R_5
$C \rightarrow DI$

$R_6 = \{HG\}$
FDs for R_6
$H \rightarrow G$

Since, FDs for $R_1 \cup R_2 \cup R_3 \cup R_4 \cup R_5 \cup R_6$ = Minimal cover, it is **dependency preserving.**

Decomposition	*A*	*B*	*C*	*D*	*E*	*G*	*H*	*I*	*J*
ABJ	a	a	a	a	a	a	a	a	a
ABE	a	a	a	a	a	a	a	a	b
DH	b	b	b	a	b	a	a	b	b
EBC	b	a	a	a	a	a	a	a	b
CDI	b	b	a	a	b	a	a	a	b
HG	b	b	b	b	b	a	a	b	b

Since there is a row that has all ‘a’, we can conclude that there is a relation that can join all the relation together and it is a **lossless join**.

Question 2 (12 marks)

Consider a relation $R(A,B,C,D,E,G,H,I,J)$ and its FD set
$F=\{AB \rightarrow CE, D \rightarrow GH, E \rightarrow BCD, C \rightarrow DI, H \rightarrow G, EH \rightarrow I\}$.

1) How many super keys can be found for R? Compute the total number of super keys and list 5 of them. (2 marks)
Ans.

For AEJ $2^{(n-3)} = 2^{(9-3)} = 2^6$
For ABJ $2^{(n-3)} = 2^{(9-3)} = 2^6$
Common Superkeys $2^{(n-4)} = 2^{(9-4)} = 2^5$

Total number of Superkeys = $2^6 + 2^6 - 2^5$ = 64+64-32 = **96**
5 Superkeys : AEJC, AEJD, AEJH, ABJI, ABJH

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

Candidate Keys are : AEJ and ABJ
Minimal Cover is:

AB→E
D→H
E→BC
C→DI
H→G

Candidate Keys are : AEJ and ABJ
Prime Attributes are : A, B, E, J
Non-Prime Attributes : C, D, G, H, I

There are FDs with no Superkeys on the left side of the FD.
Therefore, it is NOT in BCNF.

For E,
AB→E and E→BC
For C,
E→BC and C→DI
For H,
D→H and H→G
Here we can see there is a transitive dependency for E, C and H.
Therefore, it is NOT in 3NF

For functional dependencies,
AB→E and E→BC
This means there is a partial dependency .
Therefore, it is NOT in 2NF

Hence, since all values are atomic,
It is in **1NF**

3) Regarding *F*, is the decomposition $R_1 = \{ABCDE\}$, $R_2 = \{EGH\}$, $R_3 = \{EIJ\}$ of R dependency-preserving? Please justify your answer. (2 marks)
Ans.

First, find all FDs for the given relations:

$R_1 = \{ABCDE\}$
FDs for R_1
$AB \rightarrow CE$
$E \rightarrow BCD$

$R_2 = \{EGH\}$
FDs for R_2
$H \rightarrow G$

$R_3 = \{EIJ\}$
No FDs for R_3

FDs for $R_1 \cup R_2 \cup R_3 \neq$ Minimal cover, it is not dependency preserving
Since, the FDs found by the union of all three relations does not give us all the initial FDs
This decomposition is **NOT dependency preserving.**

4) Regarding *F*, is the decomposition $R_1 = \{ABCDE\}$, $R_2 = \{EGH\}$, $R_3 = \{EIJ\}$ of R lossless-join? Please justify your answer. (3 marks)
Ans.

$R(A,B,C,D,E,G,H,I,J)$
Initial Table:

Decomposition	A	B	C	D	E	G	H	I	J
$ABCDE$	a	a	a	a	a	b	b	b	b
EGH	b	b	b	b	a	a	a	b	b
EIJ	b	b	b	b	a	b	b	a	a

$AB \rightarrow CE$,
$D \rightarrow GH$,
$E \rightarrow BCD$,
$C \rightarrow DI$,
$H \rightarrow G$,
$EH \rightarrow I$

Final Table:

Decomposition	A	B	C	D	E	G	H	I	J
$ABCDE$	a	a	a	a	a	a	a	a	b
EGH	b	a	a	a	a	a	a	a	b
EIJ	b	a	a	a	a	a	a	a	a

The decomposition is lossless if one row is entirely made up by “a” values.
Since there is a row that has all ‘a’, we can conclude that it is **NOT a Lossless join.**

5) 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. (3 marks)

Ans. 3NF:

$R_1\{ABJ\}$
$R_2\{ABE\}$
$R_3\{DH\}$
$R_4\{EBC\}$
$R_5\{CDI\}$
$R_6\{HG\}$

Decompose FD AB→E since B is already dependent on E in E→BC.

BCNF:
$R_1\{ABJ\}$
$R_2\{AE\}$
$R_3\{DH\}$
$R_4\{EBC\}$
$R_5\{CDI\}$
$R_6\{HG\}$

Decomposition	*A*	*B*	*C*	*D*	*E*	*G*	*H*	*I*	*J*
ABJ	a	a	a	a	a	a	a	a	a
AE	a	a	a	a	a	a	a	a	b
DH	b	b	b	a	b	a	a	b	b
EBC	b	a	a	a	a	a	a	a	b
CDI	b	b	a	a	b	a	a	a	b
HG	b	b	b	b	b	a	a	b	b

Since there is a row that has all 'a', we can conclude that there is a relation that can join all the relation together and it is a **lossless join**.

$R_2 = \{AE\}$
FDs for R_2
A→E

$R_3 = \{DH\}$
FDs for R_3
D→H

$R_4 = \{EBC\}$
FDs for R_4
E→BC

$R_5 = \{CDI\}$
FDs for R_5
C→DI

$R_6 = \{HG\}$
FDs for R_6
H→G

Minimal Cover is:
A→E, D→H, E→BC, C→DI, H→G

Since, FDs for $R_1 \cup R_2 \cup R_3 \cup R_4 \cup R_5 \cup R_6$ = Minimal cover, it is **dependency preserving.**