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In-class Exercise 05 Schema Refinement

Q1. Please calculate A^+, G^+ and AG^+ given F = {A → B, A → C, CG → H, CG → I, B → H} and R= (A, B, C, G, H, I). What is the key of R?

Solution:

From the given F, we can obtain that

$A^+ = ABCH$

$G^+ = G$

$AG^+ = ABCGHI = R$

Thus, AG is the key of R

Q2. Given R = (A, B, C) and F = { A → B, C → B }, what is the key for R? Is R in BCNF? Why?

Solution:

From $F = \{A \to B, C \to B\}$,

we can compute $AC^+ = ABC = R$,

thus AC is the key of R

R is not in BCNF, since note that

$f_1 = A \to B$. B is not a subset of A

and A is not the candidate key of R.

For $f_2 = C \to B$, B is not a subset of C

and C is not the candidate key of R

Thus. R is not in BCNF.

Q3. Given a schema R = (A, B, C, D, E) and functional dependencies F={E → A, E → B, A → BC, B → C}. What is the key of R? Is R in 3NF? Why?

Solution:

Step 1: Find the candidate key of R

$\Rightarrow DE^+ = DEABC = R$

Thus, Key = DE

$F_c = \{E \to A, E \to B, A \to BC, B \to C\}$

$= \{E \to A, E \to B, A \to B, A \to C, B \to C\}$

$= \{E \to A, A \to B, B \to C\}$

Let $f_1 = E \to A$, $f_2 = A \to B$, $f_3 = B \to C$

For f_1, A is not a subset of E, $E \neq Key$, and

$A \subsetneq DE$

Thus, R is not in 3NF

Q4. Given R = {A,B,C,D,E} and F = {A→BC, CD →E, B → D, E→A }.

(1) R1 = {A,B,C}, R2 ={A,D,E}. Is (1) a lossless join decomposition? Why?

Solution:

find the candidate key of R

$A^+ = ABCDE = R$

Thus, A is the key of R

Verify given R1 and R2

① $A \in R1$, $A \in R2$

② $R1 \bowtie R2 = (A,B,C) \bowtie (A,D,E) = (A,B,C,D,E) = R$

Thus, this is a

Verify the result of $R1 \bowtie R2$

$\Rightarrow R1 \bowtie R2 = (A,B,C) \bowtie (A,D,E) = (A,B,C,D,E) = R$

Thus, this is a lossless join decomposition

(2) R1 = {A,B,C}, R2 ={C,D,E}. Is (2) a lossless join decomposition? Why?

Solution:

Verify the result of $R1 \bowtie R2$

$\Rightarrow R1 \bowtie R2 = (A,B,C) \bowtie (C,D,E) = (A,B,C,D,E) = R$

However, $A \notin R2$

Thus, this is not a lossless join decomposition

Q5. Given R = {A,B,C,D,E} F = {A→BC, CD →E, B → D, E→A }, we have the following decomposition:

R1 = {A,B,C}, R2 = {A,D,E}.

Is the above decomposition dependency-preserving? Why?

Solution:

To determine whether the above decomposition is dependency-preserving, we should figure out how it comes from.

$R = (A, B, C, D, E)$

$A \to BC$

$R_1 = (A, B, C)$ $\quad$ $R_2 = (A, D, E)$

From the process of decomposition stated above, we can know that only $f_1 = A \to BC$ is preserved, and the rest of the dependencies are lost.

Thus, the above decomposition is not dependency-preserving.

Q6. Given R =(A, B, C, D) and F = {C→D, C→A, B→C}.

(1) Identify $\boxed{\text{all}}$ candidate keys for R.

Solution:

From $F = \{C \to D, C \to A, B \to C\}$, we can compute

$B^+ = BCAD = R$

$\Rightarrow$ Key $= B$

(2) Is R in BCNF? If not, please decompose R into BCNF.

Solution:

We have obtained the key of R is B.

From the candidate key and dependency, we can know that R is not in BCNF.

Decompose R into BCNF

$R = (A, B, C, D)$

$C \to D$

$\underline{R_1 = (C, D)}$ $\quad$ (A, B, C)

$C \to A$

$\underline{R_2 = (A, C)}$ $\quad$ $\underline{R_3 = (B, C)}$

Thus, new relations $R_1 = (C, D)$, $R_2 = (A, C)$ and $R_3 = (B, C)$ are in BCNF

Q7. R = (A, B, C, D, E) and F = {AC→E, ACD→B, CE→D, B→E}. Please give the canonical cover of F.

Solution:

From $F = \{AC \to E, ACD \to B, CE \to D, B \to E\}$,

we compute

$F_c = \{AC \to E, ACD \to B, CE \to D, B \to E\}$

$= \{AC \to E, AC \to B, CE \to D, B \to E\}$

$= \{AC \to B, CE \to D, B \to E\}$

A, B, C, D, E, G

Q8. R = (A, B, C, D, E, ~~F~~, G, ~~H~~) and F = {AC→G, D→EG, BC→D, CG→BD, ACD→B, CE→AG}. What is the canonical cover of F? Please decompose R into 3NF.

Solution:

Compute F_c from the given F

$F_c = \{AC \to G, D \to EG, BC \to D, CG \to BD, ACD \to B, CE \to AG\}$

$= \{AC \to G, D \to E, D \to G, BC \to D, CG \to B, CG \to D, ACD \to B, CE \to A, CE \to G\}$

$= \{AC \to G, D \to E, D \to G, BC \to D, \underline{CG \to B}, CG \to D, CD \to B, CE \to A, \underline{CE \to G}\}$

$= \{AC \to G, D \to EG, BC \to D, CG \to D, CD \to B, CE \to A\}$

Find the candidate key of R

$\Rightarrow AC^+ = ACGDEB = R$

$CD^+ = CDEGAB = R$

$BC^+ = BCDEGA = R$

$CG^+ = CGDBEA = R$

$CE^+ = CEAGDB = R$

Thus, Key = {AC, CD, BC, CG, CE}

From the candidate key obtained and canonical cover, we can know that R is not in 3NF

Decompose R into 3NF

$R_1 = (A, C, G)$, $R_2 = (D, E, G)$, $R_3 = (B, C, D)$, $R_4 = (C, D, G)$, $R_5 = (A, C, E)$