 Nalawade, Rahul – rsn170330@utdallas.edu

The University of Texas at Dallas
Database Design – Prof. Nurcan, Yuruk
Assignment 04

1. Are the following sets of FDs equivalent? Explain why.
E = {A → C, AC → D, E → AD, EC → DH, DE → CH}
F = {A → CD, E → AH}

Ans.

E covers F :=

A^+ = {A, C, D}
A → A, A → C, A → D, . . . **A → CD** . . .

E^+ = {E, A, D, C, H}
E → E, E → A, . . . **E → AH** . . .

F covers E :=

A^+ = {A, C, D}
A → A, **A → C**, A → D, . . .

AC^+ = {A, C, D}
AC → D, . . .

[A → CD ==> AC → CD ==> AC → D]

E^+ = {E, A, H, C, D}
E → E, E → A, **E → AD** . . .

EC^+ = {E, C, A, D, H}
EC → DH, . . .

DE^+ = {D, E, A, C, H}
DE → CH, . . .

Here E covers F and vice-versa. Hence, E and F are quivalent.

2. Find a 3NF decomposition of a relation R(ABCDEFGHIJ) that satisfies the following FDs:
{ AB → C, BD → EF, AD- >GH, A → I, H → J, GD → ABH }
(follow regular normalization steps and successively normalize to 3NF)

Ans.
Let M = { AB → C, BD → EF, AD → GH, A → I, H → J, GD → ABH }

As using minimal cover we will be able to find and cross-check our solution.
We will first find it and then follow regular normalization method.

Doing steps: canonical form → redundant LHS part removal (none) → Tranisitive FD removal, we get:

AB → C,	BD → E,	AD → H (AD → G, AD → GD, GD → H),	AD → G,	H → J,
A → I,	BD → F ,	GD → H (GD → A, GD → AD, AD → H),	GD → A,	GD → B,

Here, we can either remove AD → H or GD → H. NOT both at the same time. Because, for one's removal we need other. So, Minimal Cover of M, removing only GD → H,

G := {	AB → C,	BD → E,	AD → H,	AD → G,	H → J,
	A → I,	BD → F ,	GD → A,	GD → B, }	

As 'D' is not present on RHS of any FD. We'll look for those having 'D' in the LHSs.
BD^+ = {B, D, E, F} **AD^+** = {A, D, G, I, B, H, E, F, J, C} **GD^+** = {G, D, A, I, B, H, E, F, J, C}

So, candidate keys = {AD, GD}. Prime attributes = {A, D, G}

1 NF: As we have keys, then we can derive all the attribute of Relation R. And given M (or G), R and the keys, there is no Multi-valued attribute, no Composite attribute and no Nested Relation.

2 NF: for R(A, B, C, D, E, F, G, H, I, J) with given keys, prime attributes = {A, D, G}
A^+ = {A, I} D^+ = {D} G^+ = {G} So, A → I is the only violation for 2 NF.
So, R = {R1, R2} where R1(A, B, C, D, E, F, G, H, J) and R2(A, I)

3 NF: we can look for violating FDs, and the decomposition, with Primary key = {AD}
AB → C, R1(A, B, D, E, F, G, H, J) R2(A, I) R3(A, B, C)
BD → EF, R1(A, B, D, G, H, J) R4(B, D, E, F)
H → J, R1(A, B, D, G, H) R5(H, J)
GD → ABH, R1(A, B, D, G, H) Here AD → GD → ABH, GD being a candidate key. Hence, no violation.
AD → HG R1(A, B, D, G, H) R2(A, I) R3(A, B, C) R4(B, D, E, F) R5(H, J)

****Doubt:** But, if we follow minimal cover method we get same decomposition, R2 to R5, except
R1 is where split into R1(A, D, G, H) and R6(A, B, D, G).

3. Find a minimal cover of the following set of dependencies:
{AB → CDE, C → BD, CD → E, DE → B }

Ans.
i. canonical form
AB → C, C → B, CD → E,
AB → D, C → D, DE → B
AB → E,

ii. redundant LHS part removal
AB → C, C → B, CD → E (redundant: C → D, C → CD, hence **C → E**),
AB → D, C → D, DE → B
AB → E,

iii. Transitive FD removal
AB → C, C → E, C → B (C → DE, DE → B),
C → D, DE → B, AB → D (AB → C, C → D),
AB → E (AB → C, C → E)

Minimal Cover:
AB → C, C → E,
DE → B, C → D

4. Consider a relation R(ABCDEFGHIJ) satisfying the following FDs:
FI → EHJC, H → GB, F → EA, HI → FGD, A → C

(a) **Find all candidate keys for R. Show all the steps. List prime attributes of R.**
(b) **Based on given functional dependencies and candidate keys that you have found, find a 3NF decomposition of R.**

(follow regular normalization steps and successively normalize to 3NF)

Ans.
(a) Given set M = {FI → EHJC, H → GB, F → EA, HI → FGD, A → C}
And as 'I' is not present on RHS of any FD. We'll look for those having 'I' in the LHSs.
FI$^+$ = {F, I, E, H, J, C, G, B, A, D} **HI**$^+$ = {H, I, F, G, D, E, J, C, B, A}

So, candidate keys = {FI, HI}. Prime attributes = {F, I, H}

(b) Given R(A, B, C, D, E, F, G, H, I, J) is already in 1 NF (no Multi-valued attribute, no Composite attribute and no Nested Relation).

2 NF: Considering closures of prime attributes,
F$^+$ = {F, E, A, C} I$^+$ = {I} H$^+$ = {H, G, B}

So, F → E, F → A, F → C, H → G, H → B violates the 2 NF condition, being partially dependent on the candidate keys { FI, HI }. So, decomposing R, we get
R1(D, F, H, I, J) R2(F, E, A, C) R3(H, G, B)

3 NF: we can look for violating FDs, and the decomposition, with Primary key = {HI}

FI → EHJC,	R1(D, F, H, I, J)	R2(F, E, A, C)	R3(H, G, B)	No violation, FI being candidate key. FI → EC is redundant.
H → GB,	R1(D, F, H, I, J)	R2(F, E, A, C)	R3(H, G, B)	
F → EA,	R1(D, F, H, I, J)	R2(F, E, A, C)	R3(H, G, B)	
HI → FGD,	R1(D, F, H, I, J)	R2(F, E, A, C)	R3(H, G, B)	HI → G is redundant. No violation.
A → C	R1(D, F, H, I, J)	R2(F, E, A)	R3(H, G, B)	R4(A, C) Creating R4.

****Doubt:** But, if we follow minimal cover method we get same decomposition, R2 to R4, except R1 is where split into R1(D, F, H, I) and R5(F, I, H, J).

5. Find a lossless (non-additive), dependency preserving 3NF decomposition of R(EFGHI) using the minimal cover method. R satisfies the following dependencies:

FG → E, HI → E, F → G, FE → H, H → I

Ans.
i. canonical form:
FG → E, HI → E, F → G, FE → H, H → I

ii. redundant LHS part removal:
H → I, FG → E (F → G, F → FG, **F → E**),
F → G, HI → E (H → I, H → HI, **H → E**),

FE → H (F → E, F → FE, **F → H**)

iii. Transitive FD removal

H → I,	F → E (F → H, H → E),
H → E,	F → G,
	F → H

Minimal Cover:

H → I,	F → H,
H → E,	F → G

So, R is decomposed into R1(H, I, E) and R2(F, H, G)

6. Consider a relation R(ABCDEFGHIJ) satisfying the following FDs:
DG → CFHB, D → CJ, F → EA, J → B, FG → DEI

(a) **Find all candidate keys for R. Show all the steps. List prime attributes of R.**
(b) **Based on given functional dependencies and candidate keys that you have found, find a 3NF decomposition of R.**

(follow regular normalization steps and successively normalize to 3NF)

Ans. (a) Given set M = {DG → CFHB, D → CJ, F → EA, J → B, FG → DEI}
And as 'G' is not present on RHS of any FD. We'll look for those having 'G' in the LHSs.
DG^+ = {D, G, C, F, H, B, J, E, A, I} **FG^+** = {F, G, D, E, I, A, B, C, H, J}

So, candidate keys = {DG, FG}. Prime attributes = {D, F, G}

(b) Given R(A, B, C, D, E, F, G, H, I, J) is already in 1 NF (no Multi-valued attribute, no Composite attribute and no Nested Relation).

2 NF: Considering closures of prime attributes,
D^+ = {D, C, J, B} F^+ = {F, E, A} G^+ = {G}

So, D → CJB, F → EA violates the 2 NF condition, being partially dependent on the candidate keys { DG, FG }. So, decomposing R, we get
R1(D, F, G, H, I) R2(D, C, J, B) R3(F, E, A)

3 NF: we can look for violating FDs, and the decomposition, with Primary key = {FG}

DG → CFHB,	R1(D, F, G, H, I)	R2(D, C, J, B)	R3(F, E, A)	No violation, DG being candidate key. DG → CB is redundant here.
D → CJ,	R1(D, F, G, H, I)	R2(D, C, J, B)	R3(F, E, A)	
F → EA,	R1(D, F, G, H, I)	R2(D, C, J, B)	R3(F, E, A)	
J → B,	R1(D, F, G, H, I)	R2(D, C, J)	R4(J, B)	Non-prime (Not C.K.) → Non-prime.
FG → DEI	R1(D, F, G, H, I)	R2(D, C, J)	R3(F, E, A)	R4(J, B) No violation. FG → E is redundant. & FG → DG → H.

****Doubt:** But, if we follow minimal cover method we get same decomposition, R2 to R4, except R1 is where split into R1(D, F, G, I) and R5(D, G, F, H).

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7. Find a lossless, dependency preserving 3NF decomposition of R(CDEFG) using the minimal cover method. R satisfies the following dependencies:

F → G, D → E, DC → F, DE → C, FG → C

Ans.

i. canonical form

F → G, D → E, DC → F, DE → C, FG → C

ii. redundant LHS part removal

F → G,	FG → C (F → G, F → FG, **F → C**),
D → E,	DE → C (D → E, D → DE, **D → C**),
	DC → F (D → C, D → DC, **D → F**)

iii. Transitive FD removal

F → G,	F → C,
D → E,	D → C (D → F, F → C),
	D → F

Minimal Cover:

F → G,	F → C,
D → E,	D → F

So, R is decomposed in R1(F, G, C) and R2(D, E, F).