Assignment 3: Functional Dependencies and Normalization

Task 1

Consider the relation schema R(A, B, C, D, E, F) and the following three FDs: FD1:

FD1: {A} → {B,C} FD2: {C} → {A,D} FD3: {D,E} → {F}

Use the Armstrong rules to derive each of the following two FDs. In both cases, describe the derivation process step by step (i.e., which rule did you apply to which FDs).

a) {C} → {B} b) {A,E} → {F}

Answer:

a) **To derive {C} → {B} :**

Apply decomposition rule to FD2:
FD4: {C} → {A}

Apply transitivity rule to FD4 and FD1
FD5: {C} → {B,C}

Apply augmentation to FD5
FD6: {C} → {B}

b) **To derive {A,E} → {F} :**

Apply decomposition rule to FD1:
FD7: {A} → {C}

Apply transitivity rule to FD7 and FD2:
FD8: {A} → {A,D}

Apply decomposition rule to FD8:
FD9: {A} → {D}

Apply augmentation to FD9:
FD10: {A,E} → {D,E}

Apply transitivity to FD10 and FD3:
FD11: {A,E} → {F}

Task 2

For the aforementioned relation schema with its functional dependencies, compute the attribute closure X^+ for each of the following two sets of attributes.

a) X = { A } b) X = { C, E }

Answer:

a) Given X ={A}, from this
X^+ = {A}

Using FD1
X^+ = {ABC}

Using FD2
X^+ = {ABCD}

b) Given X ={C,E}, from this
X^+ = {C,E}

Using FD2
X^+ = {C,A,D,E}

Using FD3
X^+ = {C,A,D,E,F}

Using FD1
X^+ = {C,A,D,E,F,B}

Task 3

Consider the relation schema R(A, B, C, D, E, F) with the following FDs

FD1: {A,B} → {C,D,E,F}

FD2: {E} → {F}

FD3: {D} → {B}

a) Determine the candidate key(s) for R.

b) Note that R is not in BCNF. Which FD(s) violate the BCNF condition?

c) Decompose R into a set of BCNF relations, and describe the process step by step (don't forget to determine the FDs and the candidate key(s) for all of the relation schemas along the way).

Answer:

a) From FD1, if we know values for both A and B, you can always get values for C, D, E, and F.
So, {A, B} is a candidate key. $\{A,B\}^+ = \{A,B,C,D,E,F\}$

From FD1 and FD3, if we know values for both A and D, you can always get values for C, D, E, and F.
So, {A, D} is also a candidate key. $\{A,D\}^+ = \{A,B,C,D,E,F\}$

We can use {A, B} or {A, D} as the candidate key for this relation.

b) Violating FDs:

FD2: {E} → {F}
The left side of FD2 is not a candidate key

FD3: {D} → {B}
The left side of FD3 is not a candidate key.

Therefore, both FD2 and FD3 violate the BCNF condition.

c) Decompose R using FD2:
R1(E, F) with FD2 and a candidate key E.

Decompose R further using FD1:
R2(A, B, C, D, E, F) with FD1 and a new FD4: {A, B} → {C, D, E} derived from decomposition of FD1. With this R1 satisfies BCNF condition.

Decomposition of R2 using FD3:
R3(D, B) with FD3 and a candidate key D.

Decompose R2 further using FD4:
R4(A, C, D, E) with FD4 and a new FD5: {A, D} → {C, E} derived from FD1 and FD3. With this R3 and R4 satisfy BCNF condition.

After normalization R consists of R1, R3, and R4:
R1(E,F) with E as candidate key.
R3(D,B) with D as candidate key.
R4(A,C,D,E) with (A,D) as candidate key.

Task 4

Consider the relation schema R(A, B, C, D, E) with the following FDs

FD1: {A,B,C} → {D,E}

FD2: {B,C,D} → {A,E}

FD3: {C} → {D}

a) Show that R is not in BCNF.

b) Decompose R into a set of BCNF relations (describe the process step by step).

Answer:

a) From the given FD's we can notice that {B, C} is a candidate key as it is not on the right-hand side of any FD. The FD3: {C} → {D} contains only C on the left-hand side. Since C is not a superkey (i.e., it's not on the right-hand side, and there are other attributes not determined by C), FD3 violates the BCNF condition.

b) Since FD3: {C} → {D} violates BCNF, lets decompose R into two relations
R1{C, D} with FD3 and the candidate key {C}.
R2{A, B, C, E} from FD1 and FD2

Derive new FD's for R2
FD4: {A, B, C} → {E} from the decomposition of FD1.
FD5: {B, C} → {A, E} from augmentation of FD3 with BC and transitivity with FD2.

R1{C, D} is in BCNF with the candidate key {C}.
R2{A, B, C, E} is in BCNF with the candidate key {B, C}.

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