CSC343 - Assignment 3

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March 30th, 2020

1. (a) **Step 1**: Split RHS of FDs.
$\{IJ \to K, J \to L, J \to I, JN \to K, JN \to M, K \to I, K \to J, K \to L, KLN \to M, M \to I, M \to J, M \to J, M \to L\}$

Step 2: LHS reduction

Consider splitting IJ:

$J^+ = LI$

$I^+ = I$

Cannot replace anything

Consider splitting JN:

$J^+ = IJLK$

$N^+ = N$

Replace $JN \to K$ with $J \to K$

Consider splitting KLN

Notice that we need N on the LHS to get M on the RHS, so only consider closures with N

$N^+ = N$

$LN^+ = LN$

$KN^+ = IJKLM$

Replace $KLN \to M$ with $KN \to M$

New set of FDs:

$\{IJ \to K, J \to L, J \to I, J \to K, JN \to M, K \to I, K \to J, K \to L, KN \to M, M \to I, M \to J, M \to J, M \to L\}$

Step 3: Remove redundant FDs

- $IJ \to K$ is removed.
- $J \to L$ is removed.
- $J \to I$ is removed.
- $J \to K$ is not removed.
- $JN \to M$ is removed.
- $K \to I$ is not removed.
- $K \to J$ is not removed.
- $K \to L$ is not removed.
- $KN \to M$ is not removed.

- $M \to I$ is removed.
- $M \to J$ is removed.
- $M \to J$ is removed.
- $M \to L$ is removed.

Minimal Basis: $\{J \to K, K \to IJL, KN \to M, M \to J\}$

(b) We have found the minimal basis on step a). Now, we must find the set of attributes not on the RHS of FD. In this case, its {N, O, P}. We find its closure, which is NOP. We see from here that every key must contain NOP.

Now we look at the attributes that aren't on the LHS of all the FD but on some RHS of the FD. These are {i, j}, which cannot be any keys for our schema.

Now we add attributes to check if its a superkey. If it is a superkey, we will check if its subset is also a super key. We will add more attributes if this is not satisfied.

$\{N, O, P\} \cup \{J\}$ is a superkey and a candidate key.
$\{N, O, P\} \cup \{K\}$ is a superkey and a candidate key.
$\{N, O, P\} \cup \{M\}$ is a superkey and a candidate key.

JNOP, KNOP, MNOP are the minimal keys for R, any other attributes can be added to them to create new super keys.

(c) **Step 1**: Minimal Basis
$\{J \to K, K \to IJL, KN \to M, M \to J\}$
Step 2: Relation creation
We get relations **JK**, **IJKL**, **KMN**, **JM** from the minimal basis.
Relation **JK** is a subset of relation **IJKL** so it is removed.
Step 3: Super Key Relation
Notice that none of the relationships contain a super key.
So we add the relation **KMNOP**.
Now we can remove **KMN** as it is a subset of **KMNOP**.
So we get the following relations for the decomposition of R
IJKL, **KMNOP**, **JM**

(d) The schema allows redundancy. The 3NF algorithm does not decompose too far, and preserves original functional dependencies, which creates redundancy. This will therefore create anomalies.

2. (a) We have $C \to EH$, $DEI \to F$, $F \to D$, $EH \to CJ$, $J \to FGI$.
Definition: We say a relation R is in BCNF if for every nontrivial FD $X \to Y$ that holds in R, X is a superkey.

- For $C \to EH$, $C^+ = CDEFGHIJ$ so the LHS of this FD is a superkey. Does not violate BCNF.
- For $DEI \to F$, $DEI^+ = DEFI$ so the LHS of this FD is **NOT** a superkey. Violates BCNF.
- For $F \to D$, $F^+ = DF$, so the LHS of this FD is **NOT** a superkey. Violates BCNF.

- For $EH \rightarrow CJ$, $EH^+ = CDEFGHIJ$ so the LHS of this FD is a superkey. Does not violate BCNF.
- For $J \rightarrow FGI$, $J^+ = DFGIJ$, so the LHS of this FD is a **NOT** superkey. Violates BCNF.

(b) Consider $DEI \rightarrow F$

$DEI^+ = DEFI$ so the new relations are DEFI and CDEGHIJ

Consider relation DEFI

The projected FDs are $\{DEI \rightarrow F, F \rightarrow D\}$

$F \rightarrow D$ violates BCNF so DEFI is decomposed into DF and EFI

Consider relation DF

The projected FDs are $\{F \rightarrow D\}$ so it is in BCNF.

Consider relation EFI

There are no projected FDs so it is in BCNF.

Consider relation CDEGHIJ

The projected FDs are $\{C \rightarrow DEGHIJ, EH \rightarrow CDGIJ, J \rightarrow DGI\}$

$J \rightarrow DGI$ violates BCNF so CDEGHIJ is split into DGIJ and CEHJ

Consider relation DGIJ

The projected FDs are $\{J \rightarrow DGI\}$ so it is in BCNF

Consider relation CEHJ

The projected FDs are $\{C \rightarrow EHJ, EH \rightarrow CJ\}$ so it is in BCNF

So the final set of relations are $\{CEHJ, DF, DGIJ, EFI\}$

The projected FDs are $\{C \rightarrow EHJ, EH \rightarrow CJ, F \rightarrow D, J \rightarrow DGI\}$