CSC343 Assignment 3: Database Design

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1. Relation R has attributes $IJKLMNOP$ and functional dependencies:

$$S_P = \{M \to IJL, J \to LI, JN \to KM, M \to J, KLN \to M, K \to IJL, IJ \to K\}$$

(a) Find a minimal basis for R.

Step 1: Split the RHSs to get our initial set of FDs, S_{p1}. We obtain:

(1) $M \to I$
(2) $M \to J$
(3) $M \to L$
(4) $J \to L$
(5) $J \to I$
(6) $JN \to K$
(7) $JN \to M$
(8) $M \to J$
(9) $KLN \to M$
(10) $K \to I$
(11) $K \to J$
(12) $K \to L$
(13) $IJ \to K$

Step 2: For each FD, try to reduce the LHS with 2+ attributes. We obtain:

(6) $JN \to K$ to $J \to K$. Since $J^+ = JLIK$, so we can reduce the LHS of this FD to just J.
(7) Since the closure of both J and N doesn't include M, so no need to reduce this FD.
(9) Since non of the closure of the singleton attributes include M, and $KN^+ = KNIJLM$, so we can reduce the LHS of this FD to KN.
(13) Using the reduced FD from (6), we know that $J \to K$. So any superset of J that determines K can be reduced to just J on the LHS.

Our new set, which we call S_{p2}:

(1) $M \to I$
(2) $M \to J$
(3) $M \to L$
(4) $J \to L$
(5) $J \to I$
(6) $J \to K$
(7) $JN \to M$
(8) $M \to J$
(9) $KN \to M$
(10) $K \to I$
(11) $K \to J$
(12) $K \to L$
(13) $J \to K$

Step 3: Try remove redundant FDs (those that are implied by others). We obtain:

(1) $M^+_{S_{p2}-\{(1)\}} = MJL\underline{I}K$. We can remove this FD.

(2) $M^+_{S_{p2}-\{(1),(2)\}} = ML$. We need this FD.

(3) $M^+_{S_{p2}-\{(1),(3)\}} = MJ\underline{L}IK$. We can remove this FD.

(4) $J^+_{S_{p2}-\{(1),(3),(4)\}} = JIK\underline{L}$. We can remove this FD.

(5) $J^+_{S_{p2}-\{(1),(3),(4),(5)\}} = JK\underline{I}L$. We can remove this FD.

(6) $J^+_{S_{p2}-\{(1),(3),(4),(5),(6)\}} = J$. We need this FD.

(7) $JN^+_{S_{p2}-\{(1),(3),(4),(5),(7)\}} = JNKIL\underline{M}$. We can remove this FD.

(8) Duplicate FD from (2). We can remove this FD.

(9) $KN^+_{S_{p2}-\{(1),(3),(4),(5),(7),(8),(9)\}} = KN$. We need this FD.

(10) $K^+_{S_{p2}-\{(1),(3),(4),(5),(7),(8),(10)\}} = KJL$. We need this FD.

(11) $K^+_{S_{p2}-\{(1),(3),(4),(5),(7),(8),(11)\}} = KIL$. We need this FD.

(12) $K^+_{S_{p2}-\{(1),(3),(4),(5),(7),(8),(12)\}} = KIJ$. We need this FD.

(13) Duplicate FD from (6). We can remove this FD.

Our final set of FDs is:

$$S_{p3} = \{M \to J, J \to K, KN \to M, K \to I, K \to J, K \to L\}$$

(b) Find all keys for R.

Attribute	LHS	RHS	Conclusion
I	✓	✓	must check
J	✓	✓	must check
K	✓	✓	must check
L	✓	✓	must check
M	✓	✓	must check
N	✓	-	must be in every key
O	-	-	must be in every key
P	-	-	must be in every key

Now checking the closure of every attribute that is in both LHS and RHS:

- $\underline{I}NOP^+ = NOPI$. Not a key.
- $\underline{J}NOP^+ = NOPJLIKM$. So $JNOP$ is a key.
- $\underline{K}NOP^+ = NOPKIJLM$. So $KNOP$ is a key.
- $\underline{L}NOP^+ = NOPL$. Not a key.
- $\underline{M}NOP^+ = NOPMIJLK$. So $MNOP$ is a key.

(c) Uses 3NF to find a lossless, dependency-preserving decomposition of R.

Revised FDs (concat rightside):

- $M \to J$
- $J \to K$
- $KN \to M$
- $K \to IJL$

From these we get four relations.

$R_1(J, M), R_2(J, K), R_3(K, N, M), R_4(I, J, K, L)$

- Since J, K occur in R_4, we don't need R_2

- Since none of the relations have attribute lists that are keys we need to add a relation that contains a key, So We'll add $R_5(N, O, P, K)$

So our final answer will be $R_1(J, M), R_5(K, N, O, P), R_3(K, M, N), R_4(I, J, K, L)$

(d) Does your schema allow redundancy? Explain why, or why not.

No because all relations are in BCNF. WILL TYPE UP explaination TMRW

2. Relation T contains attributes $CDEFGHIJ$ and functional dependencies:
$S_T = \{C \to EH, DEI \to F, F \to D, EH \to CJ, J \to FGI\}$

(a)

Which of the FDs in S_T violate BCNF?

- $C^+ = CDEFGHIJ$ so $C \to EH$ does not violate BCNF
- $DEI^+ = DEIF$ so $DEI \to F$ does violate BCNF
- $F^+ = FD$ so $F \to D$ does violate BCNF
- $EH^+ = CDEFGHIJ$ so $EH \to CJ$ does not violate BCNF
- $J^+ = JFGID$ so $J \to FGI$ does violate BCNF

(b)

Decompose T into a collection of relations that are each in BCNF.

- Decompose T using FD $DEI \to F$. $DEI^+ = DEIF$, so this yields two relations $R_1 = DEFI$ and $R_2 = CDEGHIJ$
- Project the DFs onto $R_1 = DEFI$.

D	E	F	I	closure	FDs
✓				$D^+ = D$	nothing
	✓			$E^+ = E$	nothing
		✓		$F^+ = FD$	$F \to D$; violates BCNF; abort

  We must decompose R_1 further.

- Decompose R_1 using FD $F \to D$. so this yields two relations $R_3 = FD$ and $R_4 = FEI$
- Project the FDs onto $R_3 = FD$.

F	D	closure	FDs
✓		$F^+ = FD$	$F \to D$
	✓	$D^+ = D$	nothing

- Project the FDs onto $R_4 = FEI$.

F	E	I	closure	FDs
✓			$F^+ = FD$	nothing
	✓		$E^+ = E$	nothing
		✓	$I^+ = I$	nothing
✓	✓		$FE^+ = FED$	nothing
✓		✓	$FI^+ = FI$	nothing
	✓	✓	$EI^+ = EI$	nothing

- Return to $R_2 = CDEGHIJ$ and prodject the FDs onto it.

C	D	E	G	H	I	J	closure	FDs
✓							$C^+ = CDEGHIJ$	nothing
	✓						$D^+ = D$	nothing
		✓					$E^+ = E$	nothing
			✓				$G^+ = G$	nothing
				✓			$H^+ = H$	nothing
					✓		$I^+ = I$	nothing
						✓	$J^+ = JFGID$	$J \rightarrow IDG$

- Decompose R_2 using FD $J \rightarrow IDG$. so this yields two relations $R_5 = JIDG$ and $R_6 = CEHJ$
- Project the FDs onto $R_5 = JIDG$.

J	I	D	G	closure	FDs
✓				$J^+ = JFGID$	$J \rightarrow IDG$; dont need to consider super-sets of J
	✓			$I^+ = I$	nothing
		✓		$D^+ = D$	nothing
			✓	$G^+ = G$	nothing
	✓	✓		$ID^+ = ID$	nothing
	✓		✓	$IG^+ = IG$	nothing
		✓	✓	$DG^+ = DG$	nothing

- Project the FDs onto $R_6 = CEHJ$.

C	E	H	J	closure	FDs
✓				$C^+ = CEHJFGI$	$C \rightarrow EHJ$; dont need to consider super-sets of C
	✓			$E^+ = E$	nothing
		✓		$H^+ = H$	nothing
			✓	$J^+ = J$	nothing
	✓	✓		$EH^+ = CEHJFGID$	$EH \rightarrow CEHJFGID$
	✓		✓	$EJ^+ = EJFGID$	nothing
		✓	✓	$HJ^+ = HJFGID$	nothing

So relation T containing attributes CDEFGHIJ decomposes in to relations

- $R_3 = FD$
  FDs = $\{F \rightarrow D\}$
- $R_4 = EFI$
  FDs = $\{\}$
- $R_5 = DGIJ$
  FDs = $\{J \rightarrow DGI\}$
- $R_6 = CEHJ$
  FDs = $\{EH \rightarrow CJ, C \rightarrow EH\}$