CSC343 Assignment 3: Database Design

Ryan Chang, Le Rong Shi

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:

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

(b) Find all keys for R.

Attribute	LHS	RHS	Conclusion
I	-	✓	not in any key
J	✓	✓	must check
K	✓	✓	must check
L	-	✓	not in any key
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:

- $\underline{J}NOP^{+} = NOPJLIKM$. So $JNOP$ is a key.
- $\underline{K}NOP^{+} = NOPKIJLM$. So $KNOP$ is 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):

$$R = \{M \to J, J \to K, KN \to M, K \to IJL\}$$

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.

Our schema does not allow redundancies as it follows BNFS for all tables. The closure of all the LHS of the FDs below results in all attributes of the table.

Table	FDs
Booking	(id, dive_date, listing) $\to$ (lead_diver, card_number)
Diver	(id, name, email) $\to$ (birthdate, certificate)
DiveSite	name $\to$ (location, video, snacks, shower, towel)
DiveSite	name $\to$ (open_limit, cave_limit, deep_limit)
DiveSiteCost	(dive_site, type) $\to$ cost
EquipmentCost	(name, dive_site) $\to$ cost
Listing	(id, dive_site, monitor, type, time) $\to$ cost
Monitor	(id, name) $\to$ (open_limit, cave_limit, deep_limit)
MonitorRating	(monitor, booking) $\to$ rating
SiteRating	(dive_site, diver) $\to$ rating
MonitorSite	only have trivial FDs
OtherDiver	only have trivial FDs

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.

Step 1: Decompose T using FD, $DEI \to F$. $DEI^+ = DEIF$. This yields 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.

Step 2: Decompose R_1 using FD $F \to D$. This yields 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
						✓	$J^+ = JFGID$	$J \rightarrow IDG$

Step 3: Decompose R_2 using FD $J \rightarrow IDG$. This yields relations $R_5 = JIDG$ and $R_6 = CEHJ$

Project the FDs onto $R_5 = JIDG$.

J	I	D	G	closure	FDs
✓				$J^+ = JFGID$	$J \rightarrow IDG$; no 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
✓				$C^+ = CEHJFGI$	$C \rightarrow EHJ$; no 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 $= \{EH \rightarrow CJ, C \rightarrow EH\}$