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Assignment #3

due March 3rd, 4 p.m.

1. (a) $M \to I$, $M \to J$, $M \to L$
$J \to I$, $J \to L$
$K \to I$, $K \to J$, $K \to L$
$JN \to K$, $JN \to M$
$IJ \to K$
$KLN \to M$

Simplification
For JN:
$I^+ = \{I, J, K, L\}$
$N^+ = \{N\}$
No simplification

For IJ:
$I^+ = \{I\}$
$J^+ = \{I, J, L\}$
No simplification

For KLN:
$K^+ = \{I, J, K, L\}$
$L^+ = \{L\}$
$N^+ = \{N\}$
No simplification

Redundancy
(Closure after removing relevant FD)
$M^+ = \{J, L, M\}$, $M^+ = \{I, L, M\}$, $M^+ = \{I, J, M\}$ (Keep all)
$J^+ = \{J, L\}$, $J^+ = \{I, J, K, L\}$ (Remove $J \to L$)
$K^+ = \{I, J, K, L\}$, $K^+ = \{I, K, L\}$, $K^+ = \{I, J, K\}$ (Remove $K \to I$)
$JN^+ = \{I, J, K, L, M, N\}$, $JN^+ = \{I, J, K, L, M, N\}$ (Remove $JN \to K$, then $JN \to M$)
$IJ^+ = \{I, J\}$ (Keep)
$KLN^+ = \{I, J, K, L, N\}$ (Keep)

Minimal Basis FD's

$M \to I$, $M \to J$, $M \to L$
$J \to I$
$K \to J$, $K \to L$
$IJ \to K$
$KLN \to M$

(b) N only on LHS $\to$ must be in every key
O not on LHS or RHS $\to$ must be in every key
P not on LHS or RHS $\to$ must be in every key

$INOP^+ = \{I, N, O, P\}$ (Not a key)
$JNOP^+ = \{I, J, K, L, M, N, O, P\}$ (Key)
$KNOP^+ = \{I, J, K, L, M, N, O, P\}$ (Key)
$LNOP^+ = \{L, N, O, P\}$ (Not a key)
$MNOP^+ = \{I, J, K, L, M, N, O, P\}$ (Key)
$ILNOP^+ = \{I, L, N, O, P\}$ (Not a key)
(Any superset of a key will be a superkey so we can ignore them)

(c) using the minimal basis from **(a)**
Revised FD's

$M \to IJL$
$J \to I$
$K \to JL$
$IJ \to K$
$KLN \to M$

Resulting Relations

$R1(I, J, L, M)$, $R2(I, J)$, $R3(J, K, L)$, $R4(I, J, K)$, $R5(K, L, M, N)$

We can drop $R2$ since it is a a subset of $R1$.
None contain a key of R so add a new relation that does

Final Set of Relations

$R1(I, J, L, M)$, $R3(J, K, L)$, $R4(I, J, K)$, $R5(K, L, M, N)$, $R6(J, N, O, P)$

(d) Yes. $J \to I$ can be projected onto $R1$
$J^+ = \{I, J\}$ so J is not a superkey of this relation.
So yes, this schema allows redundancy.

2. $C \to E$, $C \to H$
$DEI \to F$
$F \to D$
$EH \to C$, $EH \to J$
$J \to F$, $J \to G$, $J \to I$

(a) $C^+ = \{C, D, E, F, G, H, I, J\}$ (Superkey)
$DEI^+ = \{D, E, F, I\}$ (Not a superkey)
$F^+ = \{D, F\}$ (Not a superkey)
$EH^+ = \{C, D, E, F, G, H, I, J\}$ (Superkey)
$J^+ = \{F, G, I, J\}$ (Not a superkey)

So $DEI \to F$, $F \to D$, and $J \to FGI$ violate BCNF.

(b) **Decomposition of R using $DEI \to F$**
$R1 = DEI^+ = \{D, E, F, I\}$
$R2 = R - (R1 - \{D, E, I\}) = \{C, D, E, G, H, I, J\}$

Projection on $R1$: $DEI \to F$
$F \to D$

$DEI^+ = \{D, E, F, I\}$ (Superkey)
$F^+ = \{D, F\}$ (Not a superkey)

Projection on $R2$: $C \to EH$
$EH \to CJ$
$J \to GI$

$C^+ = \{C, D, E, G, H, I, J\}$ (Superkey)
$EH^+ = \{C, E, G, H, I, J\}$ (Not a superkey)
$J^+ = \{G, I, J\}$ (Not a superkey)

Decomposition of $R1$ using $F \to D$

$R3 = F^+ = \{D, F\}$
$R4 = R1 - (R3 - \{F\}) = \{E, F, I\}$

Projection on $R3$: $F \to D$
$F^+ = \{D, F\}$ (Superkey)

Projection on $R4$: None

So $R3, R4$ satisfy BCNF.

Decomposition of $R2$ using $J \to GI$

$R5 = J^+ = \{G, I, J\}$
$R6 = R2 - (R5 - \{J\}) = \{C, D, E, H, J\}$

Projection on $R5$: $J \to GI$

$J^+ = \{G, I, J\}$ (Superkey)

So $R5$ satisfies BCNF.

Projection on $R6$: $C \to EH$
$EH \to CJ$

$C^+ = \{C, E, H, J\}$ (Not a superkey)
$EH^+ = \{C, E, H, J\}$ (Not a superkey)

Decomposition of $R6$ using $C \to EH$

$R7 = C^+ = \{C, E, H, J\}$
$R8 = R6 - (R7 - \{C\}) = \{C, D\}$

Projection on $R7$: $C \to EH$
$EH \to CJ$

$C^+ = \{C, E, H, J\}$ (Superkey)
$EH^+ = \{C, E, H, J\}$ (Superkey)

Projection on $R8$: None

So $R7, R8$ satisfy BCNF.

Final Decomposition
$R3 = \{D, F\}$ with FD $F \to D$
$R4 = \{E, F, I\}$ with no FD's
$R5 = \{G, I, J\}$ with FD $J \to GI$
$R7 = \{C, E, H, J\}$ with FD's $C \to EH$, $EH \to CJ$
$R8 = \{C, D\}$ with no FD's