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Assignment 4
EECS 341 – Bebek
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Question 1

A) Keys: {C,D,M,P,S,T}

Candidate Keys: CM and DM

M only appears in the left side of our FD's, therefore it must be a part of our candidate key. However, M^+ = {M}, so we need to pair M with C or D. Doing so we get the entire set of keys {C,D,M,P,S,T}.

B) Use DM as candidate key and put into canonical form

C → D : Redundant	BCNF	
C → S : Not BCNF	R1 = {C,S}	C→S
DM → P : BCNF	R2 = {D,M,P,C}	DM→PC
DM → C : BCNF	R3 = {D,T}	D→T
D → T : not BCNF		

This does not preserve all dependencies because C→D is lost.

C) Use DM as candidate key and put into canonical form

C → D	3NF
C → S	R1 = {C,S,D}
DM → P	R2 = {D,M,P,C}
DM → C	R3 = {D,T}
D → T	

Question 2

Aa) $\{ACE\}^+$ = {A,B,C,D,E}

Ab) R_1 is NOT in 3NF. The FD A→B isn't trivial. A isn't a superkey of R_1, and B isn't part of a candidate key for R1.

Ac) R_1 is NOT in BCNF because it isn't in 3NF.

A BCNF decomposition:

R1a: {A,B} A→B

R1b: {C,D} C→D

R1c: {A,C,E} Included to ensure lossless join and avoid losing E entirely.

Ba) $\{AB\}^+$ = {A,B,F}

Bb) R_2 is NOT in 3NF. The FD B→F isn't trivial. B isn't a superkey of R_2, and F isn't part of a candidate key for R2.

Bc) R_2 is NOT in BCNF because it isn't in 3NF.

A BCNF decomposition:

R2a: {<u>B</u>,F} $B \rightarrow F$
R2b: {A,B} Included to ensure lossless join and avoid losing A entirely.
Note that $AB \rightarrow F$ isn't specifically included because it is trivially derived from $B \rightarrow F$.

Ca) For R_3 $\{A\}^+ = \{A,B\}$; For R_4 $\{C\}^+ = \{C,D,E,F\}$; $\{AC\}^+ = \{A,B,C,D,E,F\}$
Cb) R_3 is in 3NF. For the FD A->B, A is a superkey of R_3. R_4 is NOT in 3NF. The FD $D \rightarrow EF$ isn't a trivial FD, and D isn't a superkey of R_4, and neither E nor F are part of a superkey in R_4.
Cc) R_3 is in BCNF since A is a R_3 superkey. R_4 is NOT in BCNF because it isn't in 3NF.
A BCNF decomposition:
R3: {<u>A</u>,B} $A \rightarrow B$
R4a: {<u>C</u>,D} $C \rightarrow D$
R4b: {D,E,F} $D \rightarrow EF$

Da) $\{CDE\}^+ = \{A,B,C,D,E\}$
Db) R_5 is NOT in 3NF. The FD $D \rightarrow B$ is not trivial and D isn't a superkey of R_5, and B isn't part of a key in R_5.
Dc) R_5 is NOT in BCNF because it isn't in 3NF.
A BCNF decomposition:
R5a: {B,<u>D</u>} $D \rightarrow B$
R5b: {A,<u>C</u>,<u>E</u>} $CE \rightarrow A$

Ea) $\{ACD\}^+ = \{A,B,C,D,E\}$; $\{BCD\}^+ = \{A,B,C,D,E\}$; $\{CDE\}^+ = \{A,B,C,D,E\}$
Eb) R_6 is in 3NF. For every non-trivial FD, there is a candidate key that includes the "Y" part of $X \rightarrow Y$. For example, in $A \rightarrow E$, CDE is a candidate key, for $BC \rightarrow A$, ACD is candidate key, and for $DE \rightarrow B$, BCD is a candidate key).
Ec) R_6 is NOT in BCNF. Example, $A \rightarrow E$ isn't a trivial FD, and A isn't a superkey of R_6.
A BCNF decomposition:
R6a: {<u>A</u>,E} $A \rightarrow E$
R6b: {A,<u>B</u>,<u>C</u>} $BC \rightarrow A$
R6c: {B,<u>D</u>,<u>E</u>} $DE \rightarrow B$

Question 3

A) Attribute closure of $AB^+ = \{ABCDEF\}$
$AB \rightarrow A$
$A \rightarrow D$
$D \rightarrow C$
$D \rightarrow F$
$A \rightarrow E$
$AB \rightarrow B$

B) Lossless: After doing table of decomposition (Chase Algorithm), relation ABC has row filled with distinguished variables, therefore lossless. Also, $R_1 \cap R_3 \rightarrow R_3$.
Dependency Preserving: Not dependency preserving, for example lost $A \rightarrow D$.
Answer: This relation is lossless, not dependency preserving.

C) Lossless: After doing table of decomposition (Chase Algorithm), relation ABCE has a row filled with distinguished variables, therefore lossless. Also, $R_1 \cap R_2 \rightarrow R_2$.
Dependency Preserving: All FD's can be found in the given relations.
Answer: This relation is lossless and dependency preserving.

Question 4

A) The given set of FD's do not provide a minimum cover because there are a number of redundant variables on the RHS of the FD's. One minimal cover is:
$A \rightarrow B$ $B \rightarrow C$ $AD \rightarrow E$ $BE \rightarrow F$ $D \rightarrow G$

B) F^+ is the set of all FD's entailed by F. So $AD \rightarrow BCEFG$ and all of the FD's implied by this FD is the collection of FD's that make up F^+. The implied FD's include $AD \rightarrow A$, $AD \rightarrow D$, $AD \rightarrow AD$, $AD \rightarrow B$, $AD \rightarrow BC$, and so on. This results in over 2400 FD's.

C) $\{B\}^+$ = {B (trivial), C (FD 2)}
$\{G\}^+$ = {G (trivial)}
$\{AD\}^+$ = {A (trivial), D (trivial), B (FD 1), C (FD 3), E (FD 3), G (FD 3)}