(6) Short questions

(a) It is known that R(A,B,C,D,E) has exactly two candidate keys. What are the maximum and minimum number of superkeys R may have?

Maximum: CK
 (1) A: 16 SK
 (2) B => additional SK: (supesets of B that do not include A): 8

SK: 24

Minimum: CK: (1) ABCD, (2) ABCE => #SK: 3

(b) A relation R is in 3NF and is known to have exactly one candidate key. Can we deduce that R is also in BCNF? Prove your assertion.

If R is not in BCNF, find non-trivial FD X->Y violates BCNF, but not 3NF

1. X is not a SK.
2. Y is prime.

Y is not the full CK. Otherwise, Y->R; X->Y. Therefore, X->R then X is a superkey.

Thus, assume YZ is the CK. However, XZ is a SK and we have two candidate keys. A contradiction.

Therefore, R is in BCNF.

Error:

R1(A,B,C) {A->B, BC->A}: CK: (1) AC, (2) BC; prime: A,B,C; In 3NF; not in BCNF (A->B violates BCNF; A is not a SK.)

(c) If the relation R(A,B,C,D,E) has exactly five superkeys. Can you deduce how many candidate keys R have? Why? 2 or 4

CK: (1) A -> # of SK = 16 = number of supersets of {A} = 24.

CK: (1) AB -> # of SK = 8 = number of supersets of {A} = 23.

CK: (1) ABC -> # of SK = 4 = number of supersets of {A} = 22. ABC, ABCD, ABCE, ABCDE
 (2) ABDE -> additional SK: ABDE (supersets of ABDE: ABDE, ABCDE)

CK: (1) ABCD -> # of SK = 2 = number of supersets of {A} = 21: ABCD, ABCDE
 (2) ABCE -> Additional SK: ABCE
 (3) ABDE -> Additional SK: ABDE
 (4) ACDE -> Additional SK: ACDE

## Fall 2018 Final

(6) [25 points] Consider {AC->DF, C->ADE, AB->C, EF->BD, F->ED}

(a) What are A+, B+, C+, D+, E+ and F+?

A+: A: B+: B; C+: CADEFB; D+: D; E+: E; F+: FEDB

(b) What are the candidate keys? Show all prime attributes.

(1) C; (2) AB

(c) Give a canonical cover of F.

{AC->DF, C->ADE, AB->C, EF->BD, F->ED}

Remove extraneous attributes.

AC->DF? A is extraneous; remove A from CA->DF

{C->DF, C->ADE, AB->C, EF->BD, F->ED} simplify to

{C-> ADEF, AB->C, EF->BD, F->ED}

AB->C extraneous attributes? NO, A+: A: B+: B;

EF->BD, extraneous attributes? F+: FEDB. Yes, E Is extraneous. Remove E from EF -> BD

{C-> ADEF, AB->C, F->BD, F->ED} simplifies to

{C-> ADEF, AB->C, F->BDE}

Redundant FD?

[a] C->A redundant? {C-> DEF, AB->C, F->BDE} => C->A. No

IN {C-> DEF, AB->C, F->BDE}: C+: CDEFB (C -X->A)

[b] C->D redundant? {C-> AEF, AB->C, F->BDE} => C->D.

IN {C-> AEF, AB->C, F->BDE}: C+: CAEFBD => C->D. Yes

{C-> AEF, AB->C, F->BDE}

[c] C->E redundant? {C-> ADF, AB->C, F->BDE} => C->E.

IN {C-> ADF, AB->C, F->BDE}: C+: CADFBE => C->E. Yes

{C-> AF, AB->C, F->BDE}

AB->C, F->BDE are not redundant as C, B, D, E only appears in the RHS of these FDs.

(d) What is the highest normal form (up to BCNF) of R and why?

F->BDE violates 3NF. Highest NF: 2NF

 (e) If R is not in BCNF, can you provide a lossless FD preserving decomposition of R into BCNF relations? If yes, show such decomposition. If no, justify your answer.

Step 1: canonical cover: {C-> AF, AB->C, F->BDE}

Step 2: one relation for attribute in one FD in the canonical cover => preserve FD, in higher NF.

R1(A,C,F) {C-> AF}
R2(A,B,C) {AB->C}
R3 (B,D,E,F) {F->BDE}

Step 3: ensure that a component relation contains the original CK => lossless decomposition.

No action

Step 4: simplification.

No action