Schema Refinement
In-class Exercise (Part II)

Exercise

Consider a relation R(A,B,C,D,E,F). It has FDs:

F={AC → F, B → D, AB → CEF, ACE → B, AEF → BC}

1. Find all candidate keys of R
2. Is relation R in the 3NF? If not, give an example of FD that violates the 3NF condition and explain why.
3. Is relation R in BCNF? If not, give an example FD that violates the BCNF condition and explain why.
4. If R does not satisfy BCNF, decompose R into BCNF tables.

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Consider a relation R(A,B,C,D,E,F). It has FDs:

F={AC → F, B → D, AB → CEF, ACE → B, AEF → BC}

1. Find all candidate keys of R: AB, ACE, AEF
2. Is relation R in the 3NF? If not, give an example of FD that violates the 3NF condition and explain why.
   - R is not in 3NF (B->D violates 3NF)
3. Is relation R in BCNF? If not, give an example FD that violates the BCNF condition and explain why.

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   - R is not in 3NF (B->D violates 3NF)
3. Is relation R in BCNF? If not, give an example FD that violates the BCNF condition and explain why.
   - R is not in BCNF (AC->F, B->D violate BCNF)

Exercise

- Consider a relation R(A,B,C,D,E,F). It has FDs: F={AC → F, B → D, AB → CEF, ACE → B, AEF → BC}

1. Find all candidate keys of R: AB, ACE, AEF
2. Is relation R in the 3NF? If not, give an example of FD that violates the 3NF condition and explain why.
   - R is not in 3NF (B->D violates 3NF)
3. Is relation R in BCNF? If not, give an example FD that violates the BCNF condition and explain why.
4. If R does not satisfy BCNF, decompose R into BCNF tables.
   - The FDs AC->F and B->D violate BCNF. If we follow the order B->D first, AC->F second, we have tables ABCE, ACF, BD.

Dependency-preserving Decomposition into 3NF

Consider relation R with FDs F. Let F' be the minimal cover of F. Let R1…Rn be a lossless-join decomposition of R (can be obtained by BCNF decomposition).

- Step 1: Identify the dependencies N in F' that is not preserved by {R1, …Rn}
- Step 2: For each X-> A in N, create a relation schema XA and add it to {R1…Rn}

- It guarantees lossless-join, dependency-preserving decomposition!!!

3NF Decompostion Exercise

Consider a relation R(ABCDE), and its FDs F={ABCD→E,E→D,A→B,AC→D}.

Questions:
Q1. Does R satisfy 3NF?
Q2. If R does not satisfy 3NF, decompose R into 3NF tables.

3NF Decompostion Exercise

Consider a relation R(ABCDE), and its FDs F={ABCD→E,E→D,A→B,AC→D}.

Question Q1: Does R satisfy 3NF?

- **Step 1:** Find candidate keys
  - The candidate key is (AC)
- **Step 2**: Check 3NF satisfaction.
  - Is it true that for any FD X->Y in F, either X is a candidate key or Y is included in a candidate key?
  - ABCD->E: violates 3NF
  - E->D: violates 3NF
  - A->B: violates 3NF
  - AC->D: satisfies 3NF
- Thus R violates 3NF.

3NF Decompostion Exercise

Consider a relation R(ABCDE), and its FDs F={ABCD→E,E→D,A→B,AC→D}.

Question Q2: Decompose R into 3NF tables.

- **Step 1**: find minimal cover G of F
- **Step 2**: BCNF decomposition R(<u>AC</u>BDE) in BCNF according to G
- **Step 3**: Dependency-preserving decomposition:

  /* If X→Y is not preserved, add (XY) into the decomposition */

3NF Decompostion Exercise

Consider a relation R(ABCDE), and its FDs F={ABCD→E,E→D,A→B,AC→D}.

Question: decompose R into 3NF tables.

Step 1: find minimal cover G of F

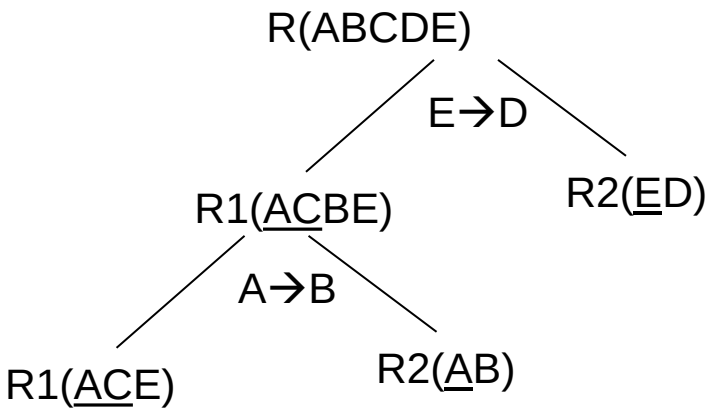
(1) make RHS contain one single attribute (No-op)
(2) minimize LHS
  Replace ABCD->E with ACD->E (because A->B)
  Replace ACD->E with AC->E (because AC->D)
(3) Remove redundant FDs
  AC->E, E->D: remove AC->D
So minimal cover = {AC→E, E→D, A→B}.

3NF Decompostion Exercise

Consider a relation R(ABCDE), and its FDs F={ABCD→E,E→D,A→B,AC→D}.

Question: decompose R into 3NF tables.

- **Step 1**: find minimal cover G of F: G={AC->E, E->D, A->B}
- **Step 2**: BCNF decomposition R(<u>AC</u>BDE) in BCNF according to G



3NF Decompostion Exercise

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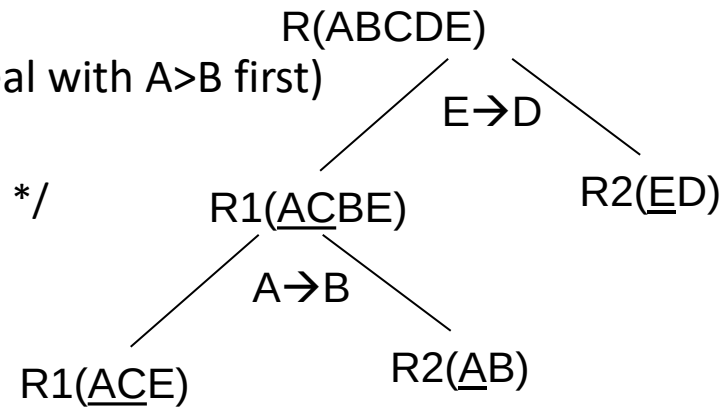
BCNF decomposition: ACE, AB, DE

(note: the decomposition result can be different if we deal with A>B first)

- **Step 3**: Dependency-preserving decomposition:

  /* If X→Y is not preserved, add (XY) into the decomposition */



Final answer:

3NF decomposition (same as BCNF decomposition): ACE, AB, DE

3NF Decompostion Exercise

Consider a relation R(ABCDE), and its FDs F={ABCD→E,E→D,A→B,AC→D}.

Question: decompose R into 3NF tables.

- **Step 1**: find minimal cover G of F: G={AC->E, E->D, A->B}
- **Step 2**: BCNF decomposition R(<u>AC</u>BDE) in BCNF according to G

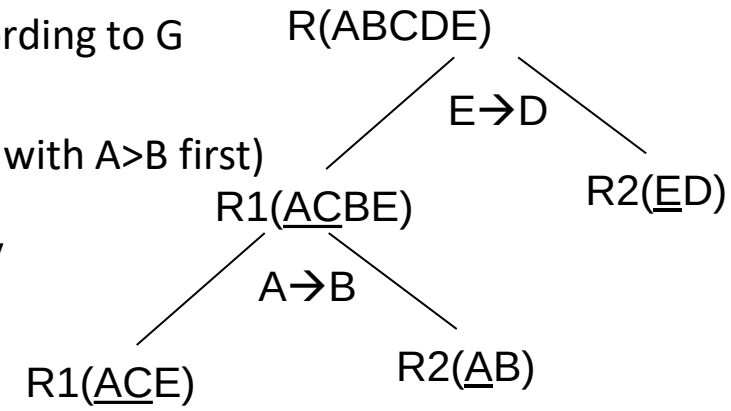
BCNF decomposition: ACE, AB, DE

(note: the decomposition result can be different if we deal with A>B first)

- **Step 3**: Dependency-preserving decomposition:

  /* If X→Y is not preserved, add (XY) into the decomposition */

  There is no new table added by Step 4



Final answer:

3NF decomposition (same as BCNF decomposition): ACE, AB, DE

Note:

- Sometimes 3NF decomposition is different from BCNF decomposition (see the lecture notes on 3NF decomposition for an example)