CS2102

Tutorial 08

NOTES

- In this slide, we will skip certain algorithms
- The algorithms skipped are
  - Algorithm #1: Attribute Closure
  - Algorithm #2: Minimal Cover
- The hope is that you are all familiar with those algorithms
  - If you are not, please seek help from either your TA or myself

Question 5(a)

- Question: *Is δ a lossless-join decomposition? Explain.*
  - **Method:**
    - Find an intermediate R_i such that one of the following is true:
      - $R \Rightarrow \{R_1, R_i\}$ and $R_i \Rightarrow \{R_2, R_3\}$ are each lossless-join decomposition
      - $R \Rightarrow \{R_2, R_i\}$ and $R_i \Rightarrow \{R_1, R_3\}$ are each lossless-join decomposition
      - $R \Rightarrow \{R_3, R_i\}$ and $R_i \Rightarrow \{R_1, R_2\}$ are each lossless-join decomposition

Question 5(a)

- Question: *Is δ a lossless-join decomposition? Explain.*
  - **Method:**
    - Find an intermediate R_i such that one of the following is true:
      - $R \Rightarrow \{R_1, R_i\}$ and $R_i \Rightarrow \{R_2, R_3\}$ are each lossless-join decomposition
      - $R \Rightarrow \{R_2, R_i\}$ and $R_i \Rightarrow \{R_1, R_3\}$ are each lossless-join decomposition
      - $R \Rightarrow \{R_3, R_i\}$ and $R_i \Rightarrow \{R_1, R_2\}$ are each lossless-join decomposition
    - Let $R_i(A, B, C, E)$
      - Decomposition of $R \Rightarrow \{R_3, R_i\}$ is a lossless-join decomposition
        - $(R_3 \cap R_i) = \{A, C\}$ and $\{A, C\} \rightarrow \{A, C, D\}$ with $R_3(A, C, D)$
      - Decomposition of $R_i \Rightarrow \{R_1, R_2\}$ is a lossless-join decomposition
        - $(R_1 \cap R_2) = \{A, B\}$ and $\{A, B\} \rightarrow \{A, B, C\}$ with $R_1(A, B, C)$

Question 5(b)

- Question: *Is δ a dependency-preserving decomposition? Explain.*
  - **Method:**
    - Since we are doing this manually, we consider only ***union minimal cover of projection***
      - $F_{R_1} = \{AB \rightarrow C\} \quad F_{R_2} = \{E \rightarrow AB\} \quad F_{R_3} = \{AC \rightarrow D\}$
      - $\left(F_{R_1} \cup F_{R_2} \cup F_{R_3}\right) = \{AB \rightarrow C,\ \ E \rightarrow AB,\ AC \rightarrow D\} = G$

Question 5(b)

- Question: *Is δ a dependency-preserving decomposition? Explain.*
  - **Method:**
    - Since we are doing this manually, we consider only *union minimal cover of projection*
      - $F_{R_1} = \{AB \to C\} \quad F_{R_2} = \{E \to AB\} \quad F_{R_3} = \{AC \to D\}$
      - $\left(F_{R_1} \cup F_{R_2} \cup F_{R_3}\right) = \{AB \to C,\ \ E \to AB,\ AC \to D\} = G$
    - Consider $F = \{AB \to C,\ \ AC \to D,\ \ E \to ABCD\}$
      - Then $F = \{AB \to C,\ \ AC \to D,\ \ E \to AB,\ E \to CD\}$ by decomposition
      - Only need to proof $G \vDash E \to CD$
      - Compute E^+ w.r.t. G, $E^+ = ABCDE$
      - Since $C \in ABCDE$ and $D \in ABCDE$ then it is dependency-preserving

Question 5(c)

- Question: *Is R in BCNF? Explain.*
  - **Method:**
    - If not BCNF $\Rightarrow$ find counterexample
    - If in BCNF $\Rightarrow$ check all FD (or run Algo #5)

Question 5(c)

- Question: *Is R in BCNF? Explain.*
  - **Method:**
    - If not BCNF ⇒ find counterexample
    - If in BCNF ⇒ check all FD (or run Algo #5)
  - **Counterexample**
    - Consider $ABC \to D$
      - $ABC \to D$ is non-trivial
      - $ABC^+ = ABCD \subset R$ $\quad\Rightarrow ABC$ is not a superkey of R

Question 5(d)

- Question: *Is* δ *in BCNF?   Explain.*
  - **Method:**
    - If not BCNF ⇒ find counterexample
    - If in BCNF ⇒ check all FD (or run Algo #5)
      - ➢All fragments!

Question 5(d)

- Question: *Is δ in BCNF? Explain.*
  - **Method:**
    - If not BCNF $\Rightarrow$ find counterexample
    - If in BCNF $\Rightarrow$ check all FD (or run Algo #5)
      - All fragments!
  - Consider only *<u>union minimal cover of projection</u>* (part (b))
    - $F_{R_1} = \{AB \to C\}$ $\Rightarrow$ AB is superkey $\Rightarrow$ R_1 is in BCNF
    - $F_{R_2} = \{E \to AB\}$ $\Rightarrow$ E is superkey $\Rightarrow$ R_2 is in BCNF
    - $F_{R_3} = \{AC \to D\}$ $\Rightarrow$ AC is superkey $\Rightarrow$ R_3 is in BCNF

Question 5(e)

- Question: *Is R in 3NF? Explain.*
  - **Method:**
    - If not 3NF $\Rightarrow$ find counterexample
    - If in 3NF $\Rightarrow$ check all FD

Question 5(e)

- Question: *Is R in 3NF? Explain.*
  - **Method:**
    - If not 3NF ⇒ find counterexample
    - If in 3NF ⇒ check all FD
  - **Counterexample:**
    - Consider $ABC \to D$
      - $ABC \to D$ is non-trivial
      - $ABC^+ = ABCD \subset R$ ⇒ ABC is not superkey
      - B is not prime attribute ⇒ keys are $\{\{E\}\}$

Question 5(f)

- Question: *Is δ in 3NF? Explain.*
  - **Method:**
    - If not 3NF $\Rightarrow$ find counterexample
    - If in 3NF $\Rightarrow$ check all FD
      - All fragments!

Question 5(f)

- Question: *Is δ in 3NF? Explain.*
  - **Method:**
    - If not 3NF $\Rightarrow$ find counterexample
    - If in 3NF $\Rightarrow$ check all FD
      - All fragments!
  - Consider only *<u>union minimal cover of projection</u>* (part (b))
    - $F_{R_1} = \{AB \rightarrow C\}$ $\Rightarrow$ AB is superkey $\Rightarrow$ R_1 is in 3NF
    - $F_{R_2} = \{E \rightarrow AB\}$ $\Rightarrow$ E is superkey $\Rightarrow$ R_2 is in 3NF
    - $F_{R_3} = \{AC \rightarrow D\}$ $\Rightarrow$ AC is superkey $\Rightarrow$ R_3 is in 3NF

Question 5(f)

- Question: *Is δ in 3NF? Explain.*
  - **Method:**
    - If not 3NF ⇒ find counterexample
    - If in 3NF ⇒ check all FD
      - ➢All fragments!
  - Consider only <u>*union minimal cover of projection*</u> (part (b))
    - $F_{R_1} = \{AB \rightarrow C\}$ ⇒ AB is superkey ⇒ R_1 is in 3NF
    - $F_{R_2} = \{E \rightarrow AB\}$ ⇒ E is superkey ⇒ R_2 is in 3NF
    - $F_{R_3} = \{AC \rightarrow D\}$ ⇒ AC is superkey ⇒ R_3 is in 3NF
    - ❖ <u>*Or simply, since δ is in BCNF, it is automatically in 3NF!*</u>

Question 6(a)

- Question: *Is δ a lossless-join decomposition? Explain.*
  - **Method:**
    - Use Theorem 1

Question 6(a)

- Question: *Is δ a lossless-join decomposition? Explain.*
  - **Method:**
    - Use Theorem 1
      - Decomposition of $R \Rightarrow \{R_1, R_2\}$ is a lossless-join decomposition
        - $(R_1 \cap R_2) = \{E\}$ and $\{E\} \rightarrow \{A, B, E\}$ with $R_3(A, B, E)$

Question 6(b)

- Question: *Is δ a dependency-preserving decomposition? Explain.*
  - **Method:**
    - Since we are doing this manually, we consider only ***union minimal cover of projection***
      - $F_{R_1} = \{E \rightarrow BD\} \quad F_{R_2} = \{A \rightarrow E,\ \ CE \rightarrow A\}$
      - $\left(F_{R_1} \cup F_{R_2}\right) = \{E \rightarrow BD,\ \ A \rightarrow E,\ CE \rightarrow A\} = G$

Question 6(b)

- Question: *Is δ a dependency-preserving decomposition? Explain.*
  - **Method:**
    - Since we are doing this manually, we consider only *union minimal cover of projection*
      - $F_{R_1} = \{E \to BD\} \quad F_{R_2} = \{A \to E,\ \ CE \to A\}$
      - $\left(F_{R_1} \cup F_{R_2}\right) = \{E \to BD,\ \ A \to E,\ CE \to A\} = G$
    - Consider $F = \{A \to E,\ \ AB \to D,\ \ CD \to AE,\ \ E \to B,\ \ E \to D\}$
      - Then $F = \{A \to E,\ \ AB \to D,\ \ CD \to AE,\ \ E \to BD\}$ by union
      - Two FDs need to be implied: $G \vDash AB \to D$ and $G \vDash CD \to AE$
        - Compute AB^+ w.r.t. G, $AB^+ = ABDE \Rightarrow G \vDash AB \to D$
        - Compute CD^+ w.r.t. G, $CD^+ = CD \quad \Rightarrow G \nvDash CD \to AE$

Question 6(b)

- Question: *Is δ a dependency-preserving decomposition? Explain.*
  - **Method:**
    - Since we are doing this manually, we consider only *union minimal cover of projection*
      - $F_{R_1} = \{E \to BD\}$ $F_{R_2} = \{A \to E,\ CE \to A\}$
      - $\left(F_{R_1} \cup F_{R_2}\right) = \{E \to BD,\ A \to E,\ CE \to A\} = G$
    - Consider $F = \{A \to E,\ AB \to D,\ CD \to AE,\ E \to B,\ E \to D\}$
      - Then $F = \{A \to E,\ AB \to D,\ CD \to AE,\ E \to BD\}$ by union
      - Two FDs need to be implied: $G \vDash AB \to D$ and $G \vDash CD \to AE$
        - Compute AB^+ w.r.t. G, $AB^+ = ABDE \Rightarrow G \vDash AB \to D$
        - Compute CD^+ w.r.t. G, $CD^+ = CD \Rightarrow G \nvDash CD \to AE$

Question 6(c)

- Question: *Is R in BCNF? Explain.*
  - **Method:**
    - If not BCNF $\Rightarrow$ find counterexample
    - If in BCNF $\Rightarrow$ check all FD (or run Algo #5)

Question 6(c)

- Question: *Is R in BCNF? Explain.*
  - **Method:**
    - If not BCNF $\Rightarrow$ find counterexample
    - If in BCNF $\Rightarrow$ check all FD (or run Algo #5)
  - **Counterexample**
    - Consider $A \rightarrow E$
      - $A \rightarrow E$ is non-trivial
      - $A^+ = ABDE \subset R \Rightarrow A$ is not a superkey of R

Question 6(d)

- Question: *Is δ in BCNF? Explain.*
  - **Method:**
    - If not BCNF ⇒ find counterexample
    - If in BCNF ⇒ check all FD (or run Algo #5)
      - All fragments!

Question 6(d)

- Question: *Is δ in BCNF? Explain.*
  - **Method:**
    - If not BCNF ⇒ find counterexample
    - If in BCNF ⇒ check all FD (or run Algo #5)
      - ➢ All fragments!
  - **Counterexample:**
    - Consider $A \to E$
      - $A \to E$ is in F_{R_2}
      - $A \to E$ is non-trivial
      - $A^+ = AE$ w.r.t. F_{R_2} ⇒ $AE \subset R_2$

Question 6(e)

- Question: *Is R in 3NF? Explain.*
  - **Method:**
    - If not 3NF ⇒ find counterexample
    - If in 3NF ⇒ check all FD

Question 6(e)

- Question: *Is R in 3NF? Explain.*
  - **Method:**
    - If not 3NF ⇒ find counterexample
    - If in 3NF ⇒ check all FD
  - **Counterexample:**
    - Consider $E \to B$
      - $E \to B$ is non-trivial
      - $E^+ = BDE \subset R$ ⇒ E is not superkey
      - B is not prime attribute ⇒ keys are $\{\{A, C\}, \{C, D\}, \{C, E\}\}$

Question 6(f)

- Question: *Is δ in 3NF? Explain.*
  - **Method:**
    - If not 3NF $\Rightarrow$ find counterexample
    - If in 3NF $\Rightarrow$ check all FD
      - All fragments!

Question 6(f)

- Question: *Is δ in 3NF? Explain.*
  - **Method:**
    - If not 3NF $\Rightarrow$ find counterexample
    - If in 3NF $\Rightarrow$ check all FD
      - All fragments!
  - Consider only *union minimal cover of projection* (part (b))
    - $F_{R_1} = \{E \to BD\}$ $\Rightarrow$ E is superkey $\Rightarrow$ R_1 is in 3NF
    - $F_{R_2} = \{CE \to A,\ \ A \to E\}$ $\Rightarrow$ CE is superkey
      $\Rightarrow$ E is prime attribute of R_2
      $\Rightarrow$ R_2 is in 3NF

Question 7(a)

- Question: *Find a lossless-join BCNF decomposition of R*
  - **Method:**
    - Algorithm 6
      - Let $\theta = \{R(A, B, C, D, E)\}$ and $\delta = \{\quad\}$

Question 7(a)

- Question: *Find a lossless-join BCNF decomposition of* R
  - **Method:**
    - Algorithm 6
      - Let $\theta = \{R(A, B, C, D, E)\}$ and $\delta = \{\quad\}$
      - Consider $R(A, B, C, D, E)$
        - Run Algo 5: $B \rightarrow DE$ violates
        - Let $\theta = \{R_1(B, D, E),\ R_2(A, B, C)\}$ and $\delta = \{\quad\}$

Question 7(a)

- Question: *Find a lossless-join BCNF decomposition of* R
  - **Method:**
    - Algorithm 6
      - Let $\theta = \{R(A, B, C, D, E)\}$ and $\delta = \{\quad\}$
      - Consider $R(A, B, C, D, E)$
        - Run Algo 5: $B \rightarrow DE$ violates
        - Let $\theta = \{R_1(B, D, E),\ R_2(A, B, C)\}$ and $\delta = \{\quad\}$
      - Consider $R_1(B, D, E)$
        - Run Algo 5: R_1 is in BCNF
        - Let $\theta = \{R_2(A, B, C)\}$ and $\delta = \{R_1(B, D, E)\}$

Question 7(a)

- Question: *Find a lossless-join BCNF decomposition of* R
  - **Method:**
    - Algorithm 6
      - Let $\theta = \{R_2(A, B, C)\}$ and $\delta = \{R_1(B, D, E)\}$
      - Consider $R_2(A, B, C)$
        - Run Algo 5: $C \rightarrow B$ violates
        - Let $\theta = \{R_3(B, C),\ R_4(A, C)\}$ and $\delta = \{R_1(B, D, E)\}$
      - Consider $R_3(B, C)$ $\Rightarrow$ In BCNF by Lemma 3
        - Let $\theta = \{R_4(A, C)\}$ and $\delta = \{R_1(B, D, E),\ R_3(B, C)\}$
      - Consider $R_4(A, C)$ $\Rightarrow$ In BCNF by Lemma 3
        - Let $\theta = \{\ \}$ and $\delta = \{R_1(B, D, E),\ R_3(B, C),\ R_4(A, C)\}$

Question 7(a)

- Question: *Find a lossless-join BCNF decomposition of* R
  - **Method:**
    - Algorithm 6
      - Let $\theta = \{\quad\}$ and $\delta = \{R_1(B, D, E),\ \ R_3(B, C),\ \ R_4(A, C)\}$
      - Done because $\theta = \{\quad\}$
      - $\delta = \{R_1(B, D, E),\ \ R_3(B, C),\ \ R_4(A, C)\}$

Question 7(a)

- Question: *Is your BCNF decomposition dependency-preserving?*
  - **Method:**
    - Compute union minimal cover of projection
      - $F_{R_1} \cup F_{R_2} \cup F_{R_3} = \{B \rightarrow DE, \;\; C \rightarrow B\} = G$
    - Consider $AB \rightarrow C$
      - Compute AB^+ w.r.t. G, $AB^+ = AB$
      - $G \nVdash AB \rightarrow C$

Question 7(b)

- Question: *Find a lossless-join and dependency-preserving 3NF decomposition of* R.
  - **Method:**
    - Compute minimal cover (Algo 2)
      - Let $G = \{B \to D,\ AB \to C,\ C \to B,\ B \to E\}$ be one minimal cover

Question 7(b)

- Question: *Find a lossless-join and dependency-preserving 3NF decomposition of R.*
  - **Method:**
    - Compute minimal cover (Algo 2)
      - Let $G = \{B \rightarrow D,\ AB \rightarrow C,\ C \rightarrow B,\ B \rightarrow E\}$ be one minimal cover
    - Construct 3NF decomposition
      - $B \rightarrow D \quad \Rightarrow R_1(B, D)$
      - $AB \rightarrow C \quad \Rightarrow R_2(A, B, C)$
      - $C \rightarrow B \quad \Rightarrow R_3(B, C)$
      - Key: $\{A, B\} \quad \Rightarrow R_4(A, B)$

Question 7(b)

- Question: *Find a lossless-join and dependency-preserving 3NF decomposition of R.*
  - **Method:**
    - Compute minimal cover (Algo 2)
      - Let $G = \{B \rightarrow D,\ AB \rightarrow C,\ C \rightarrow B,\ B \rightarrow E\}$ be one minimal cover
    - Construct 3NF decomposition
      - $B \rightarrow D \quad \Rightarrow R_1(B, D)$
      - $AB \rightarrow C \quad \Rightarrow R_2(A, B, C)$
      - $C \rightarrow B \quad \Rightarrow R_3(B, C)$
      - Key: $\{A, B\} \quad \Rightarrow R_4(A, B)$
    - Remove redundancy: $\delta = \{R_1(B, D, E),\ \ R_2(A, B, C)\}$