

Assignment 4

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1. Consider a relation R having attributes as R(ABCD), functional dependencies are given below:

$AB \rightarrow C, C \rightarrow D, D \rightarrow A$

Identify the set of candidate keys possible in relation R. List all the set of prime and non-prime attributes.

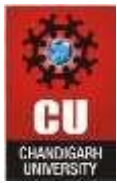
I. **Closure**

We find the closure of potential candidate keys to see which can determine all attributes (A, B, C, D).

- $(AB)^+$ :
  - Start: AB
  - Using  $AB \rightarrow C$ : ABC
  - Using  $C \rightarrow D$ : ABCD
  - $(AB)^+ = ABCD$
- $(B)^+$ :
  - Start: B. No FD has only B on the left side.  $(B)^+ = B$
- $(C)^+$ :
  - Start: C
  - Using  $C \rightarrow D$ : CD
  - Using  $D \rightarrow A$ : ACD
  - $(C)^+ = ACD$  (but missing B)
- $(BC)^+$ :
  - Start: BC
  - Using  $C \rightarrow D$ : BCD
  - Using  $D \rightarrow A$ : ABCD
  - $(BC)^+ = ABCD$
- $(BD)^+$ :
  - Start: BD
  - Using  $D \rightarrow A$ : ABD
  - Using  $AB \rightarrow C$ : ABCD
  - $(BD)^+ = ABCD$

II. **Candidate Key(s)**

From the closures, the minimal sets that can determine all attributes are: **AB, BC, and BD.**



### III. Prime and Non-Prime Attributes

- **Prime Attributes:** Attributes that are part of any candidate key (A, B, C, D).
- **Non-Prime Attributes:** There are none. All attributes are prime.

### IV. Normal Form (NF) and Why?

- **1NF:** Yes, as all attributes are atomic.
- **2NF:** Yes. There are no non-prime attributes, so partial dependencies cannot exist.
- **3NF:** Yes. Since all attributes are prime, no non-prime attribute is transitively dependent on a key (the definition of 3NF is satisfied).
- **BCNF:** **No.** The relation is **not in BCNF**. The definition of BCNF requires that for every non-trivial functional dependency  $X \rightarrow Y$ ,  $X$  must be a superkey. We have the FD  $C \rightarrow D$ .  $C$  is not a superkey (as we saw,  $(C)^+ = ACD$ , not  $ABCD$ ). Similarly,  $D \rightarrow A$  violates BCNF as  $D$  is not a superkey.
- **Conclusion:** The highest normal form is **3NF**.

### 2. Relation R(ABCDE) having functional dependencies as :

$A \rightarrow D$ ,  $B \rightarrow A$ ,  $BC \rightarrow D$ ,  $AC \rightarrow BE$

Identify the set of candidate keys possible in relation R. List all the set of prime and non-prime attributes.

#### I. Closure & II. Candidate Key(s)

Let's find a minimal superkey.

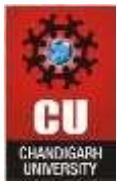
- $(B)^+$ :
  - Start: B ◦ Using  $B \rightarrow A$ : AB
  - Using  $A \rightarrow D$ : ABD (Missing C and E) •  $(C)^+$ : C (No FDs for just C) •  $(BC)^+$ :
    - Start: BC ◦ Using  $B \rightarrow A$ : ABC ◦ Using  $A \rightarrow D$ : ABCD ◦ Using  $BC \rightarrow D$ : ABCD (same)
    - $(BC)^+ = ABCD$  (Missing E)

We need to find a key that includes E. Let's try  $(AC)^+$ :

- Start: AC
- Using  $AC \rightarrow BE$ : ACBE
- Using  $A \rightarrow D$ : ACBED
- $(AC)^+ = ABCDE$

Is AC minimal? Can we find a smaller key?

- $(C)^+ = C$  (fails) •  $(A)^+$ :



- Start: A
- Using  $A \rightarrow D$ : AD (fails) So, AC is minimal.

Let's check if  $(BC)^+$  can be extended. We already have  $(BC)^+ = ABCD$ . We need an FD to get E. There is no FD with just BC or its closure on the left that gives E. Therefore, BC is not a key. **Candidate Key: AC**

### III. Prime and Non-Prime Attributes

- **Prime Attributes:** Parts of the candidate key (A, C).
- **Non-Prime Attributes:** The remaining attributes (B, D, E).

### IV. Normal Form (NF) and Why?

- **1NF:** Yes.
- **2NF:** No. There is a partial dependency. The FD  $A \rightarrow D$  is a problem. A is a subset of the candidate key AC, and it determines a non-prime attribute D. This is a partial dependency, which violates 2NF.
- **Conclusion:** The highest normal form is **1NF**.

**3. Consider a relation R having attributes as R(ABCDE), functional dependencies are given below:**

**$B \rightarrow A, A \rightarrow C, BC \rightarrow D, AC \rightarrow BE$**

**Identify the set of candidate keys possible in relation R. List all the set of prime and non-prime attributes.**

#### I. Closure & II. Candidate Key(s)

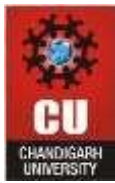
Let's find a minimal superkey.

- $(B)^+$ :
  - Start: B
  - Using  $B \rightarrow A$ : AB
  - Using  $A \rightarrow C$ : ABC
  - $(B)^+ = ABC$  (Missing D and E)

We need to get D and E. Let's try the obvious choice based on the FDs:  $(BC)^+$

- Start: BC
- Using  $B \rightarrow A$ : ABC
- Using  $BC \rightarrow D$ : ABCD
- Using  $A \rightarrow C$ : ABCD (same)
- Using  $AC \rightarrow BE$ : ABCD + BE = ABCDE
- $(BC)^+ = ABCDE$

Is BC minimal?



- $(B)^+ = ABC$  (not all)
  - $(C)^+ = C$  (not all)
- So, BC is minimal.

Let's check if B is a candidate key by itself? From above,  $(B)^+ = ABC$ , so no. **Candidate Key: BC**

### III. Prime and Non-Prime Attributes

- **Prime Attributes:** Parts of the candidate key (B, C).
- **Non-Prime Attributes:** The remaining attributes (A, D, E).

### IV. Normal Form (NF) and Why?

- **1NF:** Yes.
- **2NF:** No. There is a partial dependency. The FD  $B \rightarrow A$  is a problem. B is a subset of the candidate key BC, and it determines a non-prime attribute A. This violates 2NF.
- **Conclusion:** The highest normal form is **1NF**.

4. Consider a relation R having attributes as R(ABCDEF), functional dependencies are given below:

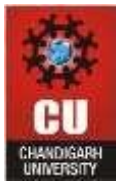
$A \rightarrow BCD$ ,  $BC \rightarrow DE$ ,  $B \rightarrow D$ ,  $D \rightarrow A$

Identify the set of candidate keys possible in relation R. List all the set of prime and non prime attributes.

#### I. Closure & II. Candidate Key(s)

Let's find the closure of single attributes to find a key.

- $(A)^+$ :
  - o Start: A      o Using  $A \rightarrow BCD$ : ABCD      o
  - o Using  $B \rightarrow D$ : ABCD (same)
  - o Using  $BC \rightarrow DE$ : ABCDE
  - o Using  $D \rightarrow A$ : ABCDE (A is already present)      o  $(A)^+ = ABCDE$  (Missing F)
- $(B)^+$ :
  - o Start: B      o Using  $B \rightarrow D$ : BD      o Using  $D \rightarrow A$ : ABD      o Using  $A \rightarrow BCD$ : ABCD (same)      o
  - o  $(B)^+ = ABCD$  (Missing E and F)



- $(D)^+$ :
  - Start: D
  - Using  $D \rightarrow A$ : AD
  - Using  $A \rightarrow BCD$ : ABCD
  - $(D)^+ = ABCD$  (Missing E and F)
- $(F)^+$ : F

None of the single attributes are keys. Let's try A with F:  $(AF)^+ = (A)^+ + F = ABCDEF$

Is AF minimal? Check  $(F)^+ = F$ , so F must be part of any key. Check if A is necessary:  $(A)^+ = ABCDE$  (missing F), so yes, A is needed.

Check  $(BF)^+$ :

- Start: BF
- Using  $B \rightarrow D$ : BDF
- Using  $D \rightarrow A$ : ABDF
- Using  $A \rightarrow BCD$ : ABCDF
- Using  $BC \rightarrow DE$ : ABCDEF  $(BF)^+ = ABCDEF$ . Is this minimal?
- $(B)^+ = ABCD$  (not all)
- $(F)^+ = F$  (not all)
- So, BF is a candidate key.

Check  $(DF)^+$ :

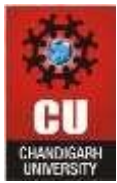
- Start: DF
- Using  $D \rightarrow A$ : ADF
- Using  $A \rightarrow BCD$ : ABCDF
- Using  $BC \rightarrow DE$ : ABCDEF
- $(DF)^+ = ABCDEF$ . It is also minimal.
- **Candidate Keys: A, BF, DF** (You could also find others like AF, but BF and DF are minimal).

### III. Prime and Non-Prime Attributes

- **Prime Attributes:** Parts of any candidate key (A, B, D, F).
- **Non-Prime Attributes:** The remaining attributes (C, E).

### IV. Normal Form (NF) and Why?

- **1NF:** Yes.
- **2NF:** Check for partial dependencies. The non-prime attributes are C and E.
  - C is determined by A ( $A \rightarrow BCD$ ). A is a candidate key itself, so this is a full functional dependency, not a partial one.
  - E is determined by BC ( $BC \rightarrow DE$ ). BC is not a superkey (is BC a candidate key? No, our candidate keys are A, BF, DF. BC is not a subset of any candidate key? B is prime, C is non-prime. This is not a partial dependency).
  - So, it seems to be in 2NF.
- **3NF:** Check for transitive dependencies. Is a non-prime attribute dependent on another non-prime?
  - Look at  $B \rightarrow D$ . D is a prime attribute (it's part of candidate keys). A non-prime attribute (C or E) is not dependent on another non-prime. The dependencies are between prime attributes or from prime to non-prime.
  - So, it seems to be in 3NF.
- **BCNF:** No. Check if the left side of every FD is a superkey.



- $B \rightarrow D$ : B is not a superkey.  $((B)^+ = ABCD)$ , which is missing E and F). This violates BCNF.
- $D \rightarrow A$ : D is not a superkey.  $((D)^+ = ABCD)$ , missing E and F). This also violates BCNF.

- **Conclusion:** The highest normal form is **3NF**.

**5. Designing a student database involves certain dependencies which are listed below:**

- $X \rightarrow Y$
- $WZ \rightarrow X$
- $WZ \rightarrow Y$
- $Y \rightarrow W$
- $Y \rightarrow X$
- $Y \rightarrow Z$

### I. Closure & II. Candidate Key(s)

Let's find a minimal superkey.

- $(Y)^+$ :
  - Start: Y
  - Using  $Y \rightarrow W$ : WY
  - Using  $Y \rightarrow X$ : WXY
  - Using  $Y \rightarrow Z$ : WXYZ
  - $(Y)^+ = WXYZ$

Is Y minimal? Yes, because no smaller set can work.

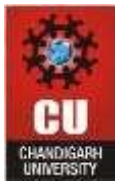
- $(WZ)^+$ :
  - Start: WZ
  - Using  $WZ \rightarrow X$ : WXZ
  - Using  $WZ \rightarrow Y$ : WXYZ
  - $(WZ)^+ = WXYZ$
  - WZ is also a candidate key.
  - **Candidate Keys: Y and WZ**

### III. Prime and Non-Prime Attributes

- **Prime Attributes:** Parts of the candidate keys (Y, W, Z).
- **Non-Prime Attributes:** There is only one other attribute: X. So, X is non-prime.

**6. Debix Pvt Ltd needs to maintain database having dependent attributes ABCDEF. These attributes are functionally dependent on each other for which functionally dependency set F given as:**

**{ $A \rightarrow BC$ ,  $D \rightarrow E$ ,  $BC \rightarrow D$ ,  $A \rightarrow D$ }** Consider a universal relation  $R_1(A, B, C, D, E, F)$  with functional dependency set F, also all attributes are simple and take atomic values



only. Find the highest normal form along with the candidate keys with prime and non-prime attribute.

### I. Closure & II. Candidate Key(s)

Let's find a minimal superkey. Notice F is not on the right side of any FD, so it must be part of every candidate key.

- $(A)^+$ :
  - Start: A ◦ Using A-  
>BC: ABC ◦ Using A->D:  
ABCD ◦ Using BC->D:  
ABCD (same) ◦ Using D->  
>E: ABCDE ◦  $(A)^+ = ABCDE$   
(Missing F)

Therefore, A alone is not a key. Let's try  $(AF)^+$ :

- $(AF)^+ = (A)^+ + F = ABCDEF$   
Is AF minimal? Check if A is necessary:  $(A)^+ = ABCDE$  (missing F). Check if F is necessary:  $(F)^+ = F$ . So both are needed.  
Is there a smaller key? Could A be replaced? No. So AF is a candidate key.  
We could also have other keys like  $(ABF)^+$ ,  $(ACF)^+$ , etc., but they are not minimal since AF is sufficient.  
**Candidate Key: AF**

### III. Prime and Non-Prime Attributes

- **Prime Attributes:** Parts of the candidate key (A, F).
- **Non-Prime Attributes:** The remaining attributes (B, C, D, E).

### IV. Normal Form (NF) and Why?

- **1NF:** Yes (as stated in the problem).
- **2NF:** No. There are partial dependencies. The candidate key is AF. Look at the FD  $A \rightarrow BC$ . A is a proper subset of the key, and it determines the non-prime attributes B and C. This is a partial dependency, which violates 2NF. Similarly,  $A \rightarrow D$  is a partial dependency.
- **Conclusion:** The highest normal form is **1NF**.