



## EXPERIMENT - 4

**Name:** Parv Bansal

**UID:** 23BCS13701

**Branch:** BE-CSE

**Section/Group:** Krg - 2A

**Semester:** 5th

**Date of Performance:** 10/09/2025

**Subject Name:** ADBMS

**Subject Code:** 23CSP-333

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

**AB→C, C→D, D→A**

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

**Solution:** Candidate Key Derivation:

- Compute closures to find minimal keys: (AB)<sup>+</sup>  
= {A, B, C, D}  
(BC)<sup>+</sup> = {B, C, D, A}  
(BD)<sup>+</sup> = {B, D, A, C}  
(A)<sup>+</sup> = {A} → A does not give B or C directly.  
(C)<sup>+</sup> = {C, D, A} (C→D, D→A) — missing B.  
(D)<sup>+</sup> = {D, A, C} (D→A, A no new C except via AB) — missing B.
- Minimal sets whose closure is all attributes are AB, BC, BD.

**Keys:**

Candidate Keys = {AB, BC, BD}

**Attributes:**

Prime Attributes = {A, B, C, D}  
Non-Prime Attributes = {} (none)

**Normalization:**

**BCNF:**

- AB → C: AB is a candidate key → OK.
  - C → D: C is not a superkey → violation.
  - D → A: D is not a superkey → violation.
- ⇒ Not in BCNF.

### 3NF

- $AB \rightarrow C$ : LHS is key  $\rightarrow$  OK.
  - $C \rightarrow D$ : D is prime (every attribute is prime)  $\rightarrow$  OK.
  - $D \rightarrow A$ : A is prime  $\rightarrow$  OK.
- $\Rightarrow$  All FDs satisfy 3NF conditions.  
Relation is in 3NF.

**Highest Normal Form = 3NF**

**Question 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 and find highest normal form.**

**Solution:** Candidate Key Derivation:

- Compute closures to find minimal keys:
  - $(A)^+ = \{A, D\}$  (from  $A \rightarrow D$ ) — missing B, C, E.
  - $(B)^+ = \{B, A, D\}$  ( $B \rightarrow A$ ,  $A \rightarrow D$ ) — missing C, E.
  - $(C)^+ = \{C\}$  — gives nothing else alone.
  - $(AC)^+ = \{A, C, B, E, D\}$  ( $AC \rightarrow BE$  gives B, E;  $B \rightarrow A$  already;  $A \rightarrow D$ ) = ABCDE.
  - $(BC)^+ = \{B, C, A, D, E\}$  ( $B \rightarrow A$ ,  $AC \rightarrow BE$  or  $BC \rightarrow D$  then  $AC \rightarrow BE$ ) = ABCDE.
  - $(AB)^+ = \{A, B, D\}$  (from  $B \rightarrow A$ ,  $A \rightarrow D$ ) — missing C, E.
- Minimal sets whose closure is all attributes are AC and BC.

**Keys:**

Candidate Keys =  $\{AC, BC\}$

**Attributes:**

Prime Attributes =  $\{A, B, C\}$  Non-Prime  
Attributes =  $\{D, E\}$

**Normalization:**

BCNF:

- $A \rightarrow D$ : A is not a key  $\rightarrow$  violation.
  - $B \rightarrow A$ : B is not a key  $\rightarrow$  violation.
  - $BC \rightarrow D$ : BC is a candidate key  $\rightarrow$  OK.
  - $AC \rightarrow BE$ : AC is a candidate key  $\rightarrow$  OK.
- $\Rightarrow$  Not in BCNF.

3NF: For each FD, check LHS is key or RHS attributes are prime:

- $A \rightarrow D$ : A not a key and D is non-prime  $\rightarrow$  violation.
- $B \rightarrow A$ : B not a key but A is prime

$\rightarrow$  OK.  $BC \rightarrow D$ : LHS is key  $\rightarrow$  OK.

- $AC \rightarrow BE$ : LHS is key  $\rightarrow$  OK.
- $\Rightarrow$  Not in 3NF (because of  $A \rightarrow D$ ).

2NF: Check partial dependencies on part of any candidate key (non-prime depending on part of a key):

Candidate keys: AC and BC. Non-prime attributes are {D, E}.

$A \rightarrow D$ : A is a proper subset of the key AC and determines non-prime D  $\rightarrow$  partial dependency  $\rightarrow$  violation.

$\Rightarrow$  Not in 2NF.

1NF: Attributes are atomic  $\rightarrow$  satisfies 1NF.

**Highest Normal Form = 1NF**

**Question 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 and find highest normal form.**

**Solution:** Candidate Key Derivation:

$(A)^+ = \{A, C\}$  (from  $A \rightarrow C$ ); from  $AC \rightarrow BE$  get B,E; with B and C,  $BC \rightarrow D$  gives D  $\rightarrow$  so  $(A)^+ = \{A, B, C, D, E\}$ .

$(B)^+ = \{B, A\}$  (from  $B \rightarrow A$ ); then  $A \rightarrow C$  gives C;  $AC \rightarrow BE$  gives E;  $BC \rightarrow D$  gives D  $\rightarrow$  so  $(B)^+ = \{A, B, C, D, E\}$ .

$(C)^+ = \{C\}$

$(D)^+ = \{D\}$

$(E)^+ = \{E\}$

**Keys:**

Candidate Keys = {A, B}

**Attributes:**

Prime Attributes = {A, B}  
Non-Prime Attributes = {C, D, E}

**Normalization:**

**BCNF:**

- $B \rightarrow A$  : B is a candidate key  $\rightarrow$  OK.
  - $A \rightarrow C$  : A is a candidate key  $\rightarrow$  OK.
  - $BC \rightarrow D$  : BC contains B (a key), so BC is a superkey  $\rightarrow$  OK.
  - $AC \rightarrow BE$  : AC contains A (a key), so AC is a superkey  $\rightarrow$  OK.
- $\Rightarrow$  All FDs have superkey LHS  $\rightarrow$  Relation is in BCNF.

**3NF:**

Since BCNF holds, 3NF is also satisfied.

**2NF:**

Candidate keys are single attributes, so there are no partial dependencies on a part of a composite key  $\rightarrow$  satisfies 2NF.

**1NF:**

Attributes are atomic  $\rightarrow$  satisfies 1NF.

**Highest Normal Form = BCNF**

**Question 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 and find highest normal form.**

**Solution:** Candidate Key Derivation:

- Attribute F never appears on the RHS of any dependency, so it must be included in every candidate key.
- Compute closures (with F included):
  - $(AF)^+$ :  $A \rightarrow BCD$  gives {A, B, C, D}; with  $BC \rightarrow DE$  we add E  $\rightarrow$  {A, B, C, D, E}; including F  $\rightarrow$   $(AF)^+ = \{A, B, C, D, E, F\}$ .
  - $(BF)^+$ :  $B \rightarrow D, D \rightarrow A$ , then  $A \rightarrow BCD$  gives {A, B, C, D}; with  $BC \rightarrow DE$  we get E  $\rightarrow$  {A, B, C, D, E}; including F  $\rightarrow$   $(BF)^+ = \{A, B, C, D, E, F\}$ .
  - $(DF)^+$ :  $D \rightarrow A$ , then  $A \rightarrow BCD$  gives {A, B, C, D}; with  $BC \rightarrow DE$  we get E  $\rightarrow$  {A, B, C, D, E}; including F  $\rightarrow$   $(DF)^+ = \{A, B, C, D, E, F\}$ .
  - $(CF)^+ = \{C, F\}$  (C alone doesn't generate others) — not a key.
  - $(EF)^+ = \{E, F\}$  — not a key.
- Minimal keys are {AF}, {BF}, {DF}.



**Keys:**

Candidate Keys = {AF, BF, DF}

**Attributes:**

Prime Attributes = {A, B,

D, F} Non-Prime

Attributes = {C, E}

**Normalization:**

**BCNF:**

- $A \rightarrow BCD$ : A is not a superkey  $\rightarrow$  violation.
  - $BC \rightarrow DE$ : BC is not a superkey  $\rightarrow$  violation.
  - $B \rightarrow D$ : B is not a superkey  $\rightarrow$  violation.
  - $D \rightarrow A$ : D is not a superkey  $\rightarrow$  violation.
- $\Rightarrow$  Not in BCNF.

**3NF:**

For each FD, either LHS is a key or RHS is prime:

- $A \rightarrow BCD$ : A not a key, RHS contains non-prime C,E  $\rightarrow$  violation.
  - $BC \rightarrow DE$ : BC not a key, RHS contains non-prime E  $\rightarrow$  violation.
  - $B \rightarrow D$ : D is prime  $\rightarrow$  OK.
  - $D \rightarrow A$ : A is prime  $\rightarrow$  OK.
- $\Rightarrow$  Not in 3NF.

**2NF:**

Candidate keys are {AF, BF, DF}. Non-prime attributes = {C, E}.

- $A \rightarrow C$ : A is part of key AF and determines non-prime C  $\rightarrow$  partial dependency  $\rightarrow$  violation.
- $\Rightarrow$  Not in 2NF.

**1NF:** Attributes are atomic  $\rightarrow$  satisfied.

**Highest Normal Form = 1NF**

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

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

The task here is to remove all the redundant FDs for efficient working of the student database management system.

**Solution:** We are given the relation  $R(W, X, Y, Z)$  with functional dependencies. Our aim is to find and remove the redundant dependencies

Write the FDs again -

1.  $X \rightarrow Y$
2.  $WZ \rightarrow X$
3.  $WZ \rightarrow Y$
4.  $Y \rightarrow W$
5.  $Y \rightarrow X$
6.  $Y \rightarrow Z$

Check redundancy one by one -

- Check FD (3):  $WZ \rightarrow Y$

From (2)  $WZ \rightarrow X$  and (1)  $X \rightarrow Y$ , we can derive  $WZ \rightarrow Y$ . So, FD (3) is redundant.

- Check FD (5):  $Y \rightarrow X$

From (6)  $Y \rightarrow Z$  and (4)  $Y \rightarrow W$ , we already have  $(W, Z)$ . Now,  $(W, Z) \rightarrow X$  (from FD 2).

Hence, from  $Y$  we can derive  $W$  and  $Z$ , then  $(WZ \rightarrow X)$ , so  $Y \rightarrow X$  is also redundant.

Final minimal cover

The essential dependencies are:

1.  $X \rightarrow Y$
2.  $WZ \rightarrow X$
3.  $Y \rightarrow W$
4.  $Y \rightarrow Z$

After removing redundant dependencies, the minimal set of functional dependencies is:

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

This is the minimal cover of the given FDs, and hence these will be used for efficient working of the student database management system.

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

**{ $A \rightarrow BC$ ,  $D \rightarrow E$ ,  $BC \rightarrow D$ ,  $A \rightarrow D$ }** Consider a universal relation  $R1(A, B, C, D, E, F)$  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 attributes.

**Solution:** Candidate Key Derivation:

- Attribute F never appears on the RHS of any dependency, so it must be included in every candidate key.  
Compute closures (with F included):
- $(AF)^+$  :  
 $A \rightarrow BC \rightarrow \{A, B, C\}$   
 $BC \rightarrow D \rightarrow \{A, B, C, D\}$   
 $D \rightarrow E \rightarrow \{A, B, C, D, E\}$   
Add F  $\rightarrow (AF)^+ = \{A, B, C, D, E, F\}$
- $(BF)^+$  :  
Start with  $\{B, F\}$ . No FD gives A. Missing  $A \rightarrow$  can't reach all attributes.  
 $\Rightarrow$  Not a key.
- $(CF)^+$  :  
Start with  $\{C, F\}$ . No FD gives A. Missing  $A \rightarrow$  not a key.
- $(DF)^+$  :  
 $D \rightarrow E \rightarrow \{D, E, F\}$ . Still missing A, B, C  $\rightarrow$  not a key.
- $(EF)^+$  :  
Start with  $\{E, F\}$ . No FD gives A. Missing A, B, C, D  $\rightarrow$  not a key. Thus the only minimal key =  $\{AF\}$ .



**Keys:**

Candidate Keys = {AF}

**Attributes:**

- Prime Attributes = {A, F}
- Non-Prime Attributes = {B, C, D, E}

**Normalization:**

**BCNF:**

$A \rightarrow BC$  : A not a superkey  $\rightarrow$  violation.  
 $A \rightarrow D$  : A not a superkey  $\rightarrow$  violation.  
 $BC \rightarrow D$  : BC not a superkey  $\rightarrow$  violation.  
 $D \rightarrow E$  : D not a superkey  $\rightarrow$  violation.  
 $\Rightarrow$  Not in BCNF

**3NF:**

$A \rightarrow BC$  : A not a key, RHS has non-prime (B,C)  $\rightarrow$  violation.  
 $A \rightarrow D$  : A not a key, D non-prime  $\rightarrow$  violation.  
 $BC \rightarrow D$  : BC not a key, D non-prime  $\rightarrow$  violation.  
 $D \rightarrow E$  : D not a key, E non-prime  $\rightarrow$  violation.  
 $\Rightarrow$  Not in 3NF

**2NF:**

Candidate key = {AF}.  
 $A \rightarrow BC$  : A is part of candidate key and determines non-prime attributes  $\rightarrow$  partial dependency  $\rightarrow$  violation.  
 $A \rightarrow D$  : Same partial dependency  $\rightarrow$  violation.  
 $\Rightarrow$  Not in 2NF

**1NF:**

All attributes are atomic  $\rightarrow$  satisfied.

**Highest Normal Form = 1NF**