

### Experiment 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.

**a) Closure**

- $(AB)^+ =$  Start AB  $\rightarrow$  by  $AB \rightarrow C$  get ABC  $\rightarrow$  by  $C \rightarrow D$  get ABCD  $\Rightarrow$  covers all.
- $(B)^+ =$  only B (no FD starts with B).
- $(C)^+ = C \rightarrow D$  (from  $C \rightarrow D$ )  $\rightarrow A$  (from  $D \rightarrow A$ )  $\Rightarrow$  ACD (B missing).
- $(BC)^+ = BC \rightarrow D$  ( $C \rightarrow D$ )  $\Rightarrow$  BCD  $\rightarrow A$  ( $D \rightarrow A$ )  $\Rightarrow$  ABCD.
- $(BD)^+ = BD \rightarrow A$  ( $D \rightarrow A$ )  $\Rightarrow$  ABD  $\rightarrow C$  ( $AB \rightarrow C$ )  $\Rightarrow$  ABCD.

**b) Candidate Keys(s)**

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

**c) Prime & 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.

**d) Normal Form 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.

### a) Closure

- $(B)^+ = B \rightarrow A \rightarrow D \Rightarrow ABD$  (C,E missing).
- $(C)^+ =$  just C.
- $(BC)^+ = BC \rightarrow A (B \rightarrow A) \Rightarrow ABC \rightarrow D (A \rightarrow D) \Rightarrow ABCD (AC \rightarrow BE) \Rightarrow ABCDE$  (all attributes)
- $(AC)^+ = AC \rightarrow BE \Rightarrow ACBE \rightarrow D (A \rightarrow D) \Rightarrow ABCDE$  (all attributes).

### b) Candidate Keys(s)

- Candidate Keys are **AC&BC**

### c) Prime & 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.

### d) Normal Form and why?

- **1NF:** Yes.
- **2NF:** No. There is a partial dependency. The functional  $A \rightarrow D$  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.

### a) Closure

- $(A)^+ = A \rightarrow C \Rightarrow AC \rightarrow BE \Rightarrow A B C E \rightarrow BC \rightarrow D \Rightarrow A B C D E$  (all attributes)
- $(B)^+ = B \rightarrow A \Rightarrow A B \rightarrow C (A \rightarrow C) \Rightarrow A B C \rightarrow AC \rightarrow BE \Rightarrow A B C E \rightarrow BC \rightarrow D \Rightarrow A B C D E$  (all attributes)
- $(C)^+ = C$ .

### b) Candidate Keys(s)

- A&B are the candidate keys.



**c) Prime & Non-Prime Attributes**

- Prime attributes: **A, B.**
- Non-prime attributes: **C, D, E.**

**d) Normal Form and why?**

- 1NF: Yes (all values atomic).
- 2NF: Yes (keys are single attributes, so no partial dependency).
- 3NF: Yes (every FD has key/superkey on LHS).
- BCNF: Yes (all FDs have superkey on LHS).

**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.**

**a) Closure**

- $(A)^+ = A \rightarrow BCD \rightarrow DE \Rightarrow ABCDE$  (F missing).
- $(B)^+ = B \rightarrow D \rightarrow A \Rightarrow AB \rightarrow BCD \Rightarrow ABCD$  (E,F missing).
- $(D)^+ = D \rightarrow A \Rightarrow AD \rightarrow BCD \Rightarrow ABCD$  (E,F missing).
- $(F)^+ =$  only F.
- Check combinations with F:
- $(AF)^+ = A's \text{ closure} + F \Rightarrow ABCDEF$ .
- $(BF)^+ = B \rightarrow D \rightarrow A \rightarrow BCD \Rightarrow ABCD + F \rightarrow BC \rightarrow DE \Rightarrow ABCDEF$ .
- $(DF)^+ = D \rightarrow A \rightarrow BCD \Rightarrow ABCD + F \rightarrow BC \rightarrow DE \Rightarrow ABCDEF$ .

**b) Candidate Keys(s)**

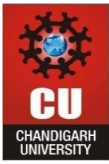
- Minimal sets whose closure gives all attributes are:  
AF, BF, DF.

**c) Prime & Non-Prime Attributes**

- Prime attributes: **A, B, D, F** (each appears in at least one candidate key).
- Non-prime attributes: **C, E.**

**d) Normal Form and why?**

- 1NF: Yes — attributes are atomic.
- 2NF: No. Reason: Candidate keys are composite (size 2). A is a proper subset of key AF, and  $A \rightarrow C$  ( $A \rightarrow C$  comes from  $A \rightarrow BCD$ ) — C is a non-prime attribute. That is a partial dependency of a non-prime on part of a candidate key, so 2NF is violated.



- Because 2NF fails, the relation cannot be in 3NF or BCNF.

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

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

### a) Closure

- $(X)^+ = X \rightarrow Y \Rightarrow Y \rightarrow W, X, Z \Rightarrow W X Y Z$  (all attributes).
- $(Y)^+ = Y \rightarrow W, X, Z \Rightarrow W X Y Z$  (all attributes).
- $(WZ)^+ = WZ \rightarrow X, Y \Rightarrow Y \rightarrow W, X, Z \Rightarrow W X Y Z$  (all attributes).
- $(W)^+ = W$ .
- $(Z)^+ = Z$ .

### b) Candidate Keys(s)

- X, Y, and WZ are candidate keys. (Each of their closures gives all attributes; W and Z individually do not, so WZ is minimal.)

### c) Prime & Non-Prime Attributes

- Prime attributes: X, Y, W, Z (each appears in at least one candidate key).
- Non-prime attributes: None.

### d) Normal Form and why?

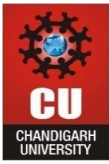
- 1NF: Yes (attributes are atomic).
- 2NF: Yes (no composite candidate key has a non-prime attribute partially dependent because either keys are single attributes X or Y, or WZ is a key but its proper subsets W and Z are not keys).
- 3NF: Yes (every FD has a superkey on the LHS or the RHS is a prime attribute).
- BCNF: Yes (all FDs have a superkey on the LHS — X, Y, and WZ are superkeys).
- Conclusion: Highest normal form = BCNF.

## 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  $R1(A, B, C, D, E, F)$  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 attribute.

### a) Closure

- $(A)^+ = A \rightarrow BC, D \rightarrow E \Rightarrow ABCDE$ . Missing F.



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- Add F:  $(AF)^+ = ABCDEF$  (all attributes).
- Neither A alone nor F alone works, so AF is minimal.

## b) Candidate Keys(s)

- AF is a candidate key (its closure gives all attributes).

## c) Prime & Non-Prime Attributes

- Prime attributes: A, F (appear in the candidate key).
- Non-prime attributes: B, C, D, E.

## d) Normal Form and why?

- 1NF: Yes (attributes are atomic).
- 2NF: No. Reason: AF is a composite key and A (a proper subset of the key) determines B, C and D ( $A \rightarrow BC$  and  $A \rightarrow D$ ). Those are non-prime attributes, so there are partial dependencies — 2NF is violated.
- 3NF / BCNF: Not applicable because 2NF already fails; the relation cannot be in 3NF or BCNF.
- Conclusion: Highest normal form = 1NF.