Experiment 4

Student Name: Gourav Sharma **UID: 23BCS10857**
Branch: CSE **Section/Group: KRG 3-A**
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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.

   a) **Closure**
      - (AB)+ = Start AB → by AB→C get ABC → by C→D get ABCD ⇒ covers all.
      - (B)+ = only B (no FD starts with B).
      - (C)+ = C → D (from C→D) → A (from D→A) ⇒ ACD (B missing).
      - (BC)+ = BC → D (C→D) ⇒ BCD → A (D→A) ⇒ ABCD.
      - (BD)+ = BD → A (D→A) ⇒ ABD → C (AB→C) ⇒ 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 -> Y, X must be a superkey. We have the FD C -> D. C is not a superkey (as we saw, (C)+ = ACD, not ABCD). Similarly, D -> 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->D, B->A, BC->D, AC->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 → A → D ⇒ ABD (C,E missing).
- (C)+ = just C.
- (BC)+ = BC → A (B→A) ⇒ ABC → D (A→D) ⇒ ABCD(AC→BE) ⇒ABCDE(all attributes)
- (AC)+ = AC → BE ⇒ ACBE → D (A→D) ⇒ 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 -> 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->A, A->C, BC->D, AC->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 → C ⇒ AC → BE ⇒ A B C E → BC → D ⇒ A B C D E.(all attributes)
- (B)+ = B → A ⇒ A B → C (A→C) ⇒ A B C → AC → BE ⇒ A B C E → BC → D ⇒ 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->BCD, BC->DE, B->D, D->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 → BCD → DE ⇒ ABCDE (F missing).
- (B)+ = B → D → A ⇒ AB → BCD ⇒ ABCD (E,F missing).
- (D)+ = D → A ⇒ AD → BCD ⇒ ABCD (E,F missing).
- (F)+ = only F.

- Check combinations with F:
- (AF)+ = A's closure + F ⇒ ABCDEF.
- (BF)+ = B → D → A → BCD ⇒ ABCD + F → BC→DE ⇒ ABCDEF.
- (DF)+ = D → A → BCD ⇒ ABCD + F → BC→DE ⇒ 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 → C (A→C comes from A→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 ->Y**
- **WZ ->X**
- **WZ ->Y**
- **Y ->W**
- **Y ->X**
- **Y ->Z**

a) Closure

- (X)+ = X → Y ⇒ Y → W, X, Z ⇒ W X Y Z (all attributes).
- (Y)+ = Y → W, X, Z ⇒ W X Y Z (all attributes).
- (WZ)+ = WZ → X, Y ⇒ Y → W, X, Z ⇒ 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 -> BC, D -> E, BC -> D, A -> 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 → BC, D → E ⇒ ABCDE. Missing F.

- 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.