

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 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 functional 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.

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.