



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**.
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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

- $(B)^+$:
 - o Start: B
 - o $B \rightarrow A \Rightarrow AB$
 - o $A \rightarrow D \Rightarrow ABD$
 - o $(B)^+ = ABD$ (missing C, E)
- $(C)^+$:
 - o Start: C
 - o $(C)^+ = C$ (no expansion)
- $(BC)^+$:
 - o Start: BC
 - o $B \rightarrow A \Rightarrow ABC$
 - o $A \rightarrow D \Rightarrow ABCD$
 - o $AC \rightarrow BE$ applies because A and C present $\Rightarrow ABCDE$
 - o $(BC)^+ = ABCDE$
- $(AC)^+$:
 - o Start: AC
 - o $AC \rightarrow BE \Rightarrow ACBE$
 - o $A \rightarrow D \Rightarrow ACBED \Rightarrow ABCDE$
 - o $(AC)^+ = ABCDE$

II. Candidate Key(s)

Minimal superkeys: **AC, BC** (both closures give ABCDE and are minimal).

III. Prime and Non-Prime Attributes

- Prime attributes: A, B, C (appear in keys AC or BC).
- Non-prime attributes: D, E.

IV. Normal Form (NF) and Why?

- 1NF: Yes.
- 2NF: **No**. Example: $A \rightarrow D$ is a partial dependency because $A \subset AC$ (a candidate key) and D is non-prime. Similarly $B \rightarrow A$ indicates partial dependency relative to BC . Thus 2NF is violated.
- 3NF / BCNF: Not applicable because 2NF fails.

Conclusion: Highest NF = 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

- $(A)^+$:
 - o Start: A
 - o $A \rightarrow C \Rightarrow AC$
 - o $AC \rightarrow BE \Rightarrow ACBE$ (adds B and E)
 - o $BC \rightarrow D$ applies (B and C present) $\Rightarrow ABCDE$
 - o $(A)^+ = ABCDE$
- $(B)^+$:
 - o Start: B
 - o $B \rightarrow A \Rightarrow AB$
 - o $A \rightarrow C \Rightarrow ABC$
 - o $AC \rightarrow BE \Rightarrow ABCDE$
 - o $(B)^+ = ABCDE$
- $(BC)^+$ (for check):
 - o Start: BC
 - o $B \rightarrow A \Rightarrow ABC$
 - o $BC \rightarrow D \Rightarrow ABCD$
 - o $AC \rightarrow BE$ (AC subset) $\Rightarrow ABCDE$
 - o $(BC)^+ = ABCDE$

II. Candidate Key(s)

Minimal superkeys found: **A, B** (each single attribute determines all attributes).

III. Prime and Non-Prime Attributes

- Prime attributes: A, B (occur in candidate keys).
- Non-prime attributes: C, D, E.

IV. Normal Form (NF) and Why?

- 1NF: Yes.
- 2NF: Yes — candidate keys are single attributes, so partial dependency (as defined w.r.t composite keys) does not arise.

- 3NF: Yes — for every FD $X \rightarrow Y$ either X is a superkey or Y is prime. All FDs have X as a superkey here (because A and B are keys) or result in prime RHS.
 - BCNF: **Yes**. Check each FD: $B \rightarrow A$ (B is key), $A \rightarrow C$ (A is key), $BC \rightarrow D$ (BC contains B so BC is superkey), $AC \rightarrow BE$ (AC contains A so AC is superkey). All determinants are superkeys.
- Conclusion:** Highest NF = **BCNF**.

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.

. Closure

- $(A)^+$:
 - o Start: A
 - o $A \rightarrow BCD \Rightarrow ABCD$
 - o $BC \rightarrow DE$ (BC subset of $ABCD$) $\Rightarrow ABCDE$
 - o $(A)^+ = ABCDE$ (missing F)
- $(F)^+$: F (alone)
- $(AF)^+$:
 - o Start: AF
 - o $A \rightarrow BCD \Rightarrow ABCDF$
 - o $BC \rightarrow DE \Rightarrow ABCDEF$
 - o $(AF)^+ = ABCDEF$
- $(BF)^+$:
 - o Start: BF
 - o $B \rightarrow D \Rightarrow BDF$
 - o $D \rightarrow A \Rightarrow ABDF$
 - o $A \rightarrow BCD \Rightarrow ABCDF$
 - o $BC \rightarrow DE \Rightarrow ABCDEF$
 - o $(BF)^+ = ABCDEF$
- $(DF)^+$:
 - o Start: DF
 - o $D \rightarrow A \Rightarrow ADF$
 - o $A \rightarrow BCD \Rightarrow ABCDF$
 - o $BC \rightarrow DE \Rightarrow ABCDEF$
 - o $(DF)^+ = ABCDEF$

II. Candidate Key(s)

Minimal superkeys: **AF, BF, DF** (each minimal and determines all attributes).

III. Prime and Non-Prime Attributes

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

IV. Normal Form (NF) and Why?

- 1NF: Yes.
- 2NF: Yes — non-prime attributes (C, E) are fully dependent on candidate keys (no partial dependency).
- 3NF: Yes — non-prime attributes are not transitively dependent on keys in a way that violates 3NF. Also when an FD $X \rightarrow Y$ has X not a superkey, the RHS attribute is prime (so 3NF condition satisfied).
- BCNF: **No**. Example: $B \rightarrow D$ (B is not a superkey), $D \rightarrow A$ (D not a superkey). These violate BCNF.

Conclusion: Highest NF = 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

- $(X)^+$:
 - Start: X
 - $X \rightarrow Y \Rightarrow XY$
 - $Y \rightarrow W, X, Z \Rightarrow WXYZ$
 - $(X)^+ = WXYZ$
- $(Y)^+$:
 - Start: Y
 - $Y \rightarrow W, X, Z \Rightarrow WXYZ$
 - $(Y)^+ = WXYZ$
- $(WZ)^+$:
 - Start: WZ
 - $WZ \rightarrow X \Rightarrow WXZ$
 - $WZ \rightarrow Y \Rightarrow WXYZ$
 - $(WZ)^+ = WXYZ$

II. Candidate Key(s)

Minimal superkeys: **X, Y, WZ** (all give closure = WXYZ; X and Y are single-attribute keys; WZ is a two-attribute key).

III. Prime and Non-Prime Attributes

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

IV. Normal Form (NF) and Why?

- 1NF: Yes.
- 2NF: Yes (no non-prime attributes \rightarrow no partial dependency).
- 3NF: Yes (every FD $X \rightarrow Y$ has X a superkey or Y is prime).
- BCNF: **Yes.** Every FD has determinant that is a superkey: X , Y and WZ are keys — so BCNF holds.

Conclusion: Highest NF = **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.

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 $A \rightarrow BC$: ABC
 - Using $A \rightarrow D$: $ABCD$
 - Using $BC \rightarrow D$: $ABCD$ (same)
 - Using $D \rightarrow E$: $ABCDE$
 - $(A)^+ = ABCDE$ (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).



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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**.