

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**.

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 & II. Candidate Key(s)

Let's find a minimal superkey.

- $(B)^+$:
 - Start: B
 - Using $B \rightarrow A$: AB
 - Using $A \rightarrow D$: ABD (Missing C and E)
- $(C)^+$: C (No FDs for just C)
- $(BC)^+$:
 - Start: BC
 - Using $B \rightarrow A$: ABC
 - Using $A \rightarrow D$: ABCD
 - Using $BC \rightarrow D$: ABCD (same)
 - $(BC)^+ = ABCD$ (Missing E)

We need to find a key that includes E. Let's try $(AC)^+$:

- Start: AC
- Using $AC \rightarrow BE$: ACBE
- Using $A \rightarrow D$: ACBED
- $(AC)^+ = ABCDE$

Is AC minimal? Can we find a smaller key?

- $(C)^+ = C$ (fails)
- $(A)^+$:
 - Start: A
 - Using $A \rightarrow D$: AD (fails)So, AC is minimal.

Let's check if $(BC)^+$ can be extended. We already have $(BC)^+ = ABCD$. We need an FD to get E. There is no FD with just BC or its closure on the left that gives E. Therefore, BC is not a key.

Candidate Key: AC

III. Prime and Non-Prime Attributes

- **Prime Attributes:** Parts of the candidate key (A, C).
- **Non-Prime Attributes:** The remaining attributes (B, D, E).

IV. Normal Form (NF) and Why?

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

I. Closure & II. Candidate Key(s)

Let's find a minimal superkey.

- $(B)^+$:
 - Start: B
 - Using $B \rightarrow A$: AB
 - Using $A \rightarrow C$: ABC
 - $(B)^+ = ABC$ (Missing D and E)

We need to get D and E. Let's try the obvious choice based on the FDs: $(BC)^+$

- Start: BC
- Using $B \rightarrow A$: ABC
- Using $BC \rightarrow D$: ABCD
- Using $A \rightarrow C$: ABCD (same)
- Using $AC \rightarrow BE$: ABCD + BE = ABCDE
- $(BC)^+ = ABCDE$

Is BC minimal?

- $(B)^+ = ABC$ (not all)
 - $(C)^+ = C$ (not all)
- So, BC is minimal.

Let's check if B is a candidate key by itself? From above, $(B)^+ = ABC$, so no.

Candidate Key: BC

III. Prime and Non-Prime Attributes

- **Prime Attributes:** Parts of the candidate key (B, C).
- **Non-Prime Attributes:** The remaining attributes (A, D, E).

IV. Normal Form (NF) and Why?

- **1NF:** Yes.
- **2NF:** No. There is a partial dependency. The FD $B \rightarrow A$ is a problem. B is a subset of the candidate key BC, and it determines a non-prime attribute A. This violates 2NF.
- **Conclusion:** The highest normal form is **1NF**.

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.

I. Closure & II. Candidate Key(s)

Let's find the closure of single attributes to find a key.

- $(A)^+$:
 - Start: A
 - Using $A \rightarrow BCD$: ABCD
 - Using $B \rightarrow D$: ABCD (same)
 - Using $BC \rightarrow DE$: ABCDE
 - Using $D \rightarrow A$: ABCDE (A is already present)
 - $(A)^+ = ABCDE$ (Missing F)
- $(B)^+$:
 - Start: B
 - Using $B \rightarrow D$: BD
 - Using $D \rightarrow A$: ABD
 - Using $A \rightarrow BCD$: ABCD (same)
 - $(B)^+ = ABCD$ (Missing E and F)
- $(D)^+$:
 - Start: D
 - Using $D \rightarrow A$: AD
 - Using $A \rightarrow BCD$: ABCD
 - $(D)^+ = ABCD$ (Missing E and F)

- (F)⁺: F

None of the single attributes are keys. Let's try A with F: (AF)⁺ = (A)⁺ + F = ABCDEF

Is AF minimal? Check (F)⁺ = F, so F must be part of any key. Check if A is necessary: (A)⁺ = ABCDE (missing F), so yes, A is needed.

Check (BF)⁺:

- Start: BF
- Using B→D: BDF
- Using D→A: ABDF
- Using A→BCD: ABCDF
- Using BC→DE: ABCDEF
- (BF)⁺ = ABCDEF. Is this minimal?
- (B)⁺ = ABCD (not all)
- (F)⁺ = F (not all)
- So, BF is a candidate key.

Check (DF)⁺:

- Start: DF
- Using D→A: ADF
- Using A→BCD: ABCDF
- Using BC→DE: ABCDEF
- (DF)⁺ = ABCDEF. It is also minimal.
- **Candidate Keys: A, BF, DF** (You could also find others like AF, but BF and DF are minimal).

III. Prime and Non-Prime Attributes

- **Prime Attributes:** Parts of any candidate key (A, B, D, F).
- **Non-Prime Attributes:** The remaining attributes (C, E).

IV. Normal Form (NF) and Why?

- **1NF:** Yes.
- **2NF:** Check for partial dependencies. The non-prime attributes are C and E.
 - C is determined by A (A→BCD). A is a candidate key itself, so this is a full functional dependency, not a partial one.
 - E is determined by BC (BC→DE). BC is not a superkey (is BC a candidate key? No, our candidate keys are A, BF, DF. BC is not a subset of any candidate key? B is prime, C is non-prime. This is not a partial dependency.
 - So, it seems to be in 2NF.
- **3NF:** Check for transitive dependencies. Is a non-prime attribute dependent on another non-prime?
 - Look at B→D. D is a prime attribute (it's part of candidate keys). A non-prime attribute (C or E) is not dependent on another non-prime. The dependencies are between prime attributes or from prime to non-prime.
 - So, it seems to be in 3NF.
- **BCNF:** No. Check if the left side of every FD is a superkey.
 - B→D: B is not a superkey. ((B)⁺ = ABCD, which is missing E and F). This violates BCNF.
 - D→A: D is not a superkey. ((D)⁺ = ABCD, missing E and F). This also violates BCNF.
- **Conclusion:** The highest normal form is **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 & II. Candidate Key(s)

Let's find a minimal superkey.

- $(Y)^+$:
 - Start: Y
 - Using $Y \rightarrow W$: WY
 - Using $Y \rightarrow X$: WXY
 - Using $Y \rightarrow Z$: WXYZ
 - $(Y)^+ = WXYZ$

Is Y minimal? Yes, because no smaller set can work.

- $(WZ)^+$:
 - Start: WZ
 - Using $WZ \rightarrow X$: WXZ
 - Using $WZ \rightarrow Y$: WXYZ
 - $(WZ)^+ = WXYZ$

WZ is also a candidate key.
Candidate Keys: Y and WZ

III. Prime and Non-Prime Attributes

- **Prime Attributes:** Parts of the candidate keys (Y, W, Z).
- **Non-Prime Attributes:** There is only one other attribute: X. So, X is non-prime.

IV. Normal Form (NF) and Why?

- **1NF:** Yes (assumed).
 - **2NF:** Yes. There is only one non-prime attribute (X). For the key Y, it's a single attribute key, so no partial dependency is possible. For the key WZ, the non-prime attribute X is dependent on the full key WZ (from $WZ \rightarrow X$), so no partial dependency.
 - **3NF:** Yes. The only non-prime attribute is X, and it is directly dependent on the candidate keys ($Y \rightarrow X$ and $WZ \rightarrow X$). There is no transitive dependency.
 - **BCNF:** No. Check all FDs. The FD $X \rightarrow Y$ is a problem. X is a non-prime attribute, and it determines Y, which is a prime attribute. But for BCNF, the left side of *every* FD must be a superkey. X is not a superkey. This violates BCNF.
 - **Conclusion:** The highest normal form is 3NF.
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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).
- **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**.