Experiment - 4

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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.

1. 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->C: ABC
  - Using C->D: ABCD
  - (AB)+ = ABCD
- (B)+:
  - Start: B. No FD has only B on the left side. (B)+ = B
- (C)+:
  - Start: C
  - Using C->D: CD
  - Using D->A: ACD
  - (C)+ = ACD (but missing B)
- (BC)+:
  - Start: BC
  - Using C->D: BCD
  - Using D->A: ABCD
  - (BC)+ = ABCD
- (BD)+:
  - Start: BD
  - Using D->A: ABD
  - Using AB->C: ABCD
  - (BD)+ = ABCD

2. Candidate Key(s)

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

3. 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.

4. 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 -> Y, X must be a super key. 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 super key.
- **Conclusion:** The highest normal form is **3NF**.

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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.

1. Closure

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

2. Candidate Key(s)

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

3. Prime and Non-Prime Attributes

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

4. **Normal Form (NF) and Why?**
   - 1NF: Yes.
   - 2NF: **No.** Example: A → D is a partial dependency because A ⊂ AC (a candidate key) and D is non-prime. Similarly B → A indicates partial dependency relative to BC. Thus 2NF is violated.
   - 3NF / BCNF: Not applicable because 2NF fails.

   Conclusion: Highest NF = **1NF**.

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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.

1. **Closure**

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

2. **Candidate Key(s)**
   Minimal super keys found: **A, B** (each single attribute determines all attributes).

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

4. **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 → 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 → A (B is key), A → C (A is key), BC → D (BC contains B so BC is superkey), AC → BE (AC contains A so AC is superkey). All determinants are superkeys. **Conclusion:** Highest NF = **BCNF**.

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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.

1. Closure

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

2. Candidate Key(s)
Minimal super keys: **AF, BF, DF** (each minimal and determines all attributes).

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

4. **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→Y has X not a superkey, the RHS attribute is prime (so 3NF condition satisfied).
 • BCNF: **No.** Example: B → D (B is not a superkey), D → A (D not a superkey). These violate BCNF.
 Conclusion: Highest NF = **3NF**.

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

- **X ->Y**
- **WZ ->X**
- **WZ ->Y**
- **Y ->W**
- **Y ->X**
- **Y ->Z**

1. **Closure**

- (X)+:
  - o Start: X
  - o X → Y ⇒ XY
  - o Y → W,X,Z ⇒ WXYZ
  - o (X)+ = WXYZ
- (Y)+:
  - o Start: Y
  - o Y → W,X,Z ⇒ WXYZ
  - o (Y)+ = WXYZ
- (WZ)+:
  - o Start: WZ
  - o WZ → X ⇒ WXZ
  - o WZ → Y ⇒ WXYZ
  - o (WZ)+ = WXYZ

2. **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).

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

4. **Normal Form (NF) and Why?**
   - 1NF: Yes.
   - 2NF: Yes (no non-prime attributes → no partial dependency).
   - 3NF: Yes (every FD X→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**.

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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 -> 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.

1. 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->BC: ABC
  - Using A->D: ABCD
  - Using BC->D: ABCD (same)
  - Using D->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.

2. Candidate Key: AF

3. Prime and Non-Prime Attributes

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

5. Normal Form (NF) and Why?

- **1NF:** Yes (as stated in the problem).

is AF. Look at the FD A->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->D is a partial dependency.

- **Conclusion:** The highest normal form is **1NF**.