Experiment – 4.2

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Aim: To analyze given relations with functional dependencies, determine candidate keys, classify prime and non-prime attributes, remove redundant dependencies, and identify the highest normal form of the relation schemas.

Objective: The objective of this work is to analyze functional dependencies in given relations to determine candidate keys and classify attributes as prime or non-prime. It also focuses on minimizing functional dependencies by removing redundancy and evaluating the highest normal form achieved by each relation.

Q1:
For relation R(A,B,C,D) with FDs {AB→C, C→D, D→A}, find candidate keys, prime and non-prime attributes. Also state the highest normal form.

Dependencies: AB→C, C→D, D→A

Solution:

- Candidate Keys: **AB, BC, BD**
- Prime Attributes: **A, B, C, D**
- Non-Prime Attributes: **Ø**

Explanation:
AB+ = {A,B,C,D}, BC+ = {B,C,D,A}, BD+ = {B,D,A,C}. All attributes are prime.

Highest Normal Form = **3NF** (C→D violates BCNF but is allowed in 3NF since D is prime).

Q2:
For relation R(A,B,C,D,E) with FDs {A→D, B→A, BC→D, AC→BE}, find candidate keys, prime and non-prime attributes. Also state the highest normal form.

Dependencies: A→D, B→A, BC→D, AC→BE

Solution:
- Candidate Keys: **AC, BC**
- Prime Attributes: **A, B, C**
- Non-Prime Attributes: **D, E**

Explanation:
AC+ = {A,B,C,D,E}, BC+ = {B,C,A,D,E}. Both are keys. Non-primes {D,E} depend only on part of key (A), so violates 2NF.

Highest Normal Form = **1NF**.

Q3:
For relation R(A,B,C,D,E) with FDs {B→A, A→C, BC→D, AC→BE}, find candidate keys, prime and non-prime attributes. Also state the highest normal form.

Dependencies: B→A, A→C, BC→D, AC→BE

Solution:
- Candidate Keys: **A, B**
- Prime Attributes: **A, B**
- Non-Prime Attributes: **C, D, E**

Explanation:
A+ = {A,C,B,E,D}, B+ = {B,A,C,D,E}. Both generate full set. Since all LHS are keys, no violations.

Highest Normal Form = **BCNF**.

Q4:
For relation R(A,B,C,D,E,F) with FDs {A→BCD, BC→DE, B→D, D→A}, find candidate keys, prime and non-prime attributes. Also state the highest normal form.

Dependencies: A→BCD, BC→DE, B→D, D→A

Solution:
- Candidate Keys: **AF, BF, DF**
- Prime Attributes: **A, B, D, F**
- Non-Prime Attributes: **C, E**

Explanation:
A+ = {A,B,C,D,E}, missing F → AF is key. Similarly BF and DF. Partial dependencies (A→C,E) mean it fails 2NF.

Highest Normal Form = **1NF**.

Q5:
For relation R(W,X,Y,Z) with FDs {X→Y, WZ→X, WZ→Y, Y→W, Y→X, Y→Z}, find candidate keys, prime and non-prime attributes, minimal cover, and highest normal form.

Dependencies: X→Y, WZ→X, WZ→Y, Y→W, Y→X, Y→Z

Solution:
- Minimal Cover: **{X→Y, WZ→X, Y→W, Y→Z}**
- Candidate Keys: **X, Y, WZ**
- Prime Attributes: **W, X, Y, Z**
- Non-Prime Attributes: **∅**
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Explanation:
Y+ = {Y,W,X,Z}, X+ = {X,Y,W,Z}, WZ+ = {W,Z,X,Y}. All attributes are prime.

Highest Normal Form = **BCNF** (all FDs have LHS as key).

Q6:
For relation R1(A,B,C,D,E,F) with FDs {A→BC, A→D, BC→D, D→E}, find candidate keys, prime and non-prime attributes. Also state the highest normal form.

Dependencies: A→BC, A→D, BC→D, D→E

Solution:

- Candidate Key: **AF**
- Prime Attributes: **A, F**
- Non-Prime Attributes: **B, C, D, E**

Explanation:
A+ = {A,B,C,D,E}, missing F → AF is key. Non-primes depend only on part of key, violating 2NF.

Highest Normal Form = **1NF**.

Learning Outcomes

After completing these questions, students will be able to:

1. Apply closure method to find candidate keys.
2. Differentiate prime and non-prime attributes in a relation.
3. Detect and eliminate redundant functional dependencies.
4. Identify the highest normal form of a given relation schema.
5. Improve conceptual clarity of normalization for efficient database design.