DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
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Experiment 4

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Semester: 5th
Date of Performance: 8th September 2025
Subject Name: ADBMS
Subject Code: 23CSP-333

1. Aim:

To study the concepts of functional dependencies, candidate keys, prime and non-prime attributes, and normalization in relational databases, and to apply them to identify the highest normal form of a given relation.

2. Objective:

- To understand functional dependencies and their role in database design.
- To determine candidate keys for a given relation using closure method.
- To differentiate between prime and non-prime attributes.
- To analyze a relation schema and identify the highest normal form (1NF, 2NF, 3NF, BCNF) it satisfies.
- To learn how redundant functional dependencies can be removed.

4. Questions and Answers

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Q 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.

Solution (i) Closure of AB

$AB^+ = \{A, B\}$
$AB^+ = \{A, B, C\}$
$AB^+ = \{A, B, C, D\}$

$\therefore$ AB is a Candidate key

(ii) Closure of BC

$BC^+ = \{B, C\}$
$BC^+ = \{B, C, D\}$
$BC^+ = \{B, C, D, A\}$

$\therefore$ BC is a Candidate key

(iii) Closure of BD

$BD^+ = \{B, D\}$
$BD^+ = \{B, D, A\}$
$BD^+ = \{B, D, A, C\}$

∴ BD is a Candidate key

(iv) Closure of CD

$CD^+ = \{C, D\}$
$CD^+ = \{C, D, A\} \neq \{A, B, C, D\}$

∴ CD is not a Candidate key

(v) Closure of AD

$AD^+ = \{A, D\} \neq \{A, B, C, D\}$
∴ AD^+ is not a Candidate Key

(vi) $A^+ = \{A\}$ $B^+ = \{B\}$
$C^+ = \{C, D\}$
$C^+ = \{C, D, A\}$
$D^+ = \{D\}$
$D^+ = \{D, A\}$

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∴ Candidate keys: AB, BC, BD

→ Prime and non-prime attributes
· Candidate keys = {AB, BC, BD}

∴ Prime attributes = {A, B, C, D}
Non-prime " = { }

Q. R(ABCDE)
A → D, B → A, BC → D, AC → BE

Identify Candidate Keys in R
List all prime and non-prime attributes

→ Closure of A

$A^+ = \{A\}$
$A^+ = \{A, D\} \neq \{A, B, C, D, E\}$

→ Closure of B
$B^+ = \{B\}$
$B^+ = \{B, A\}$
$B^+ = \{B, A, D\} \neq \{A, B, C, D\}$

→ Closure of C

$C^+ = \{C\} \neq \{A, B, C, D, E\}$

→ Closure of BC

$BC^+ = \{B, C\}$

$BC^+ = \{B, C, A\}$

$BC^+ = \{B, C, A, D\}$

$\Rightarrow BC^+ = \{B, C, A, D, E\}$

$= \{A, B, C, D, E\}$

∴ BC is a Candidate key.

→ Closure of AC

$AC^+ = \{A, C\}$

$AC^+ = \{A, C, B, E\}$

$AC^+ = \{A, C, B, E, D\} = \{A, B, C, D, E\}$

AC is a Candidate key

Closure of AB

$AB^+ = \{A, B\}$

$AB^+ = \{A, B, D\} \neq \{A, B, C, D, E\}$

Candidate keys: AC, BC

Prime attributes: {A, B, C}
Non-prime attributes: {D, E}

Q R(ABCDE)

$B \to A$, $A \to C$, $BC \to D$, $AC \to BE$
Identify Candidate keys in R and Prime and Non-prime attributes

closure of B:

$B^+ = \{B\}$
$B^+ = \{B, A\}$
$B^+ = \{B, A, C\}$
$B^+ = \{B, A, C, D\}$

$B^+ = \{B, A, C, D, E\}$

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∴ B is a Candidate key

Closure of C

$B_{C^+} = \{C\}$

Closure of A

$A^+ = \{A, C\}$
$A^+ = \{A, C, B, E\}$
$A^+ = \{A, C, B, E, D\}$

∴ A is a Candidate key

~~Also~~ No need to check AC, and BC as A and B are both minimal. Also AB need not be checked

Candidate keys = $\{A, B\}$
Prime attributes = $\{A, B\}$
Non-Prime attributes = $\{C, D, E\}$

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Q. $R(ABCDEF)$

FDs :

$A \rightarrow BCD$

$BC \rightarrow DE$

$B \rightarrow D$

$D \rightarrow A$

Since No dependency gives us us F, it shall be included with all Candidate keys.

$AF^+ = \{A, F, B, C, D\}$

$AF^+ = \{A, F, B, C, D, E\}$

∴ AF is Candidate Key

$BF^+ = \{B, F, D\}$

$BF^+ = \{B, F, D, A\}$

$BF^+ = \{B, F, D, A, C\}$

$BF^+ = \{B, F, D, A, C, E\}$

∴ BF a Candidate Key

$CF^+ = \{C, F\}$

$EF^+ = \{E, F\}$

$DF^+ = \{D, F, A\}$

Since AF is a candidate key:

$DF^+ = \{D, F, A, B, C, E\}$

$\therefore$ A is a candidate key

$\therefore$ Candidate keys = AF, BF, DF

→ Prime attributes = {A, B, D, F}

→ Non-prime attributes = {C, E}

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Q. Design Student DB involving certain dependencies which are listed below:

1) $X \rightarrow Y$
2) $WZ \rightarrow X$
3) $WZ \rightarrow Y$
4) $Y \rightarrow W$
5) $Y \rightarrow W$
6) $Y \rightarrow Z$

Remove all redundant FDs for efficient working of the student database management system.

~~[illegible]~~

$WZ \rightarrow X$ and $X \rightarrow Y \rightarrow WZ \rightarrow Y$

$\therefore WZ \rightarrow Y$ is redundant

→ remove (3)

→ Write minimal set (Canonical Cover)

$X \rightarrow Y$ $\quad$ $Y \rightarrow Z$

$WZ \rightarrow X$

$Y \rightarrow W$

$Y \rightarrow X$

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$\therefore$ { $X \to Y$, $WZ \to X$, $Y \to W$, $Y \to Z$, $Y \to X$ }

is one possible student Database removing all Redundant FDs

Q. 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:
{ $A \to BC$, $D \to E$, $BC \to D$, $A \to D$ } Consider a universal relation R1(A, B, C, D, E, F) with FD set F, also all attributes are simple and take atomic values only. Find the highest normal form along with Candidate Keys with prime and non-prime attribute.

→ Sol: Relation:
$R(A, B, C, D, E, F)$

FDs F:
$A \to BC$
$D \to E$
$BC \to D$
$A \to D$

Find Candidate Keys

$A^+ = \{A\}$
$A^+ = \{A, B, C\}$
$A^+ = \{A, B, C, D\}$
$A^+ = \{A, B, C, D, E\}$
Not Candidate Key
But, F not determined anywhere, shall be part of all Candidate Keys.

→ Since A determines all except F.

$AF^+ = \{A, B, C, D, E, F\}$
AF is Candidate Key

No other combination (not including AF) provide / determines all attributes.

No other attribute other than A can determine A.

∴ AF is the only candidate key

→ Prime attributes = {A, F}
⇒ Non-Prime attributes = {B, C, D, E}

→ Normal form
- 1NF: yes (atomic attributes)

Check 2NF:
A → BC (A ⊂ key, BC are non prime)
∴ Partial dependency exists
Not in 2NF
Only 1NF
Candidate keys = {AF}
Prime attributes = {A, F}
Non-" " = {B, C, D, E}
Highest NF = 1NF

5. Learning Outcomes:

- Define and explain functional dependencies in relational schema.
- Find candidate keys and classify attributes into prime and non-prime.
- Detect partial, transitive, and trivial dependencies.
- Identify the highest normal form satisfied by a relation.
- Apply normalization techniques to design efficient and consistent database schemas.