Database Management System (DBMS)

Lecture-36

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Axioms for Multivalued dependency

(1) Replication rule:

$X \rightarrow Y \Rightarrow X \rightarrow\rightarrow Y$

(2) Reflexivity rule:

$X \rightarrow\rightarrow X$

(3) Augmentation rule:

$X \rightarrow\rightarrow Y \Rightarrow XZ \rightarrow\rightarrow Y$

(4) Union rule:

$X \rightarrow\rightarrow Y$ and $X \rightarrow\rightarrow Z \Rightarrow X \rightarrow\rightarrow YZ$

(5) Complementation rule:

$X \rightarrow\rightarrow Y \Rightarrow X \rightarrow\rightarrow (R - X - Y)$

(6) Transitivity rule:

$X \rightarrow\rightarrow Y$ and $Y \rightarrow\rightarrow Z \Rightarrow X \rightarrow\rightarrow (Z - Y)$

(7) Intersection rule:

$X \rightarrow\rightarrow Y$ and $X \rightarrow\rightarrow Z \Rightarrow X \rightarrow\rightarrow (Y \cap Z)$

(8) Difference rule:

$X \rightarrow\rightarrow Y$ and $X \rightarrow\rightarrow Z \Rightarrow X \rightarrow\rightarrow (Y - Z)$ *and* $X \rightarrow\rightarrow (Z - Y)$

(9) Pseudo transitivity rule:

$X \rightarrow\rightarrow Y$ and $XY \rightarrow\rightarrow Z \Rightarrow X \rightarrow\rightarrow (Z - Y)$

(10) Coalescence rule:

Given that $W \subseteq Y$ and $Y \cap Z = \phi$, and if $X \rightarrow\rightarrow Y$ and $Z \rightarrow W$ then $X \rightarrow W$.

Closure under Multivalued dependency

Let D be the set of functional and multivalued dependencies.
The closure of D is the set of all functional and multivalued dependencies that are logically implied by D. It is denoted by D^+.
Example: Consider R = (A, B, C, G, H, I)
and F $=\{A \to\to B,\ B \to\to HI,\ CG \to H\}$
Find some members of D^+.
Solution: Some members of D^+ are the following:-

- $A \to\to CGHI$, By complementation rule in $A \to\to B$
- $A \to\to HI$, By transitivity rule in $A \to\to B$ and $B \to\to HI$
- $B \to H$, By coalescence rule in $B \to\to HI$ and $CG \to H$
- $A \to\to CG$, By difference rule in $A \to\to CGHI$ and

Fourth Normal Form(4NF)

A relation schema R is in fourth normal form(4NF) with respect to a set D of functional and multivalued dependencies if, for all multivalued dependencies in D^+ of the form $\alpha \rightarrow\rightarrow \beta$, where $\alpha \subseteq R$ and $\beta \subseteq R$, at least one of the following holds:

- $\alpha \rightarrow\rightarrow \beta$ is a trivial multivalued dependency.
- α is a super key for schema R.

Note: Every 4NF schema is in BCNF.

Decomposition in to 4NF

Following algorithm is used to decompose schema R into 4NF.

Input: Relation schema R and set D

Output: $R_1, R_2, ..., R_m$

result $\leftarrow R$

done=false

Compute D^+

while *not done* **do**

  if *(there is a schema R_i in result that is not in 4NF w.r.t. D_i)* **then**

    let $\alpha \rightarrow\rightarrow \beta$ be a nontrivial multivalued dependency that holds on R_i such that $\alpha \rightarrow R_i$ is not in D_i, and $\alpha \cap \beta = \phi$

    $result \leftarrow (result - R_i) \cup (R_i - \beta) \cup (\alpha, \beta)$

  end

  else

    done = true

  end

end

Example: Consider the following relation schema.

loan-number	customer-name	customer-street	customer-city
L-23	Smith	North	Rye
L-23	Smith	Main	Manchester
L-93	Curry	Lake	Horseneck

Find out this table is in 4NF or not. If not, then decompose it into 4NF.

Solution: In this table, multivalued dependency

$$\text{customer-name} \rightarrow\rightarrow \text{customer-street customer-city}$$

holds.

Clearly, neither this multivalued dependency is trivial nor customer-name is super key. Therefore, this table is not in 4NF.

By using above algorithm, this table is decomposed as

$R_1 =$ (customer-name, loan-number)

$R_2 =$ (customer-name, customer-street, customer-city)

Now, R_1 and R_2 are in 4NF.

Join dependency

Given a relation schema R. let $R_1, R_2, \ldots\ldots\ldots\ldots, R_n$ are the projections of R. A relation r(R) satisfies the join dependency $*(R_1, R_2, \ldots\ldots\ldots\ldots, R_n)$, iff the join of the projection of r on R_i, $1 \leq i \leq n$, is equal to r.

$$r = \Pi_{R_1} \bowtie \Pi_{R_2} \bowtie \Pi_{R_3} \bowtie \ldots\ldots\ldots \bowtie \Pi_{R_n}$$

Trivial join dependency

A join dependency is trivial if one of the projections of R is R itself.

Project join normal form(PJNF) or 5NF

Consider a relation schema R and D is the set of functional, multi-valued and join dependencies.
The relation R is in Project join normal form with respect to D if for every join dependency *$(R_1, R_2, ..., R_n)$, either of the following holds:-
(i) The join dependency is trivial.
(ii) Every R_i is a super key of R.