COMPUTER SCIENCE

Database Management System

FD's & Normalization

Lecture_03

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TOPICS TO BE COVERED

01 Attribute Closure

02 Finding Candidate keys

RDBMS Concept

FD Concept

<u>FD types</u>

1. Trivial FD
2. Non Trivial FD
3. Semi Non Trivial FD.

Note Trivial FD are always Valid.

Trivial FD

$X \to y$ is Trivial

$X \supseteq y$.

$AB \to A$

$AB \to B$

$AB \to AB$

Non Trivial FD

$X \cap y = \phi$ & FD Defination SatisFy.

$A \to B$

$AB \to C$

Q.10 Consider the relation X(P, Q, R, S, T, U) with the following set of functional dependencies

[2015: 1 Marks]

$$F = \{ \\ \{P, R\} \rightarrow \{S, T\} \\ \{P, S, U\} \rightarrow \{Q, R\} \\ \}$$

Which of the following is the trivial functional dependency in F^+ is closure of F?

(A) $\{P, R\} \rightarrow \{S, T\}$

(B) $\{P, R\} \rightarrow \{R, T\}$

(C) $\{P, S\} \rightarrow \{S\}$

(D) $\{P, S, U\} \rightarrow \{Q\}$

$X \longrightarrow y$

(a) $PR \rightarrow ST$ $\quad X \cap Y = \phi$ Non Trivial.

(b) $PR \rightarrow RT$ $\quad$ Semi Non Trivial $\quad [AB \rightarrow BC]$

$X \supseteq Y$ & $X \cap Y \neq \phi$

(c) $\underline{PS} \rightarrow S$ $\quad \underline{X} \supseteq y$ Trivial FD.

(d) $PSU \rightarrow Q$ $\quad$ Non Trivial $\because X \cap Y = \phi$

Armstrong's Axioms/Inference Rules

Properties of FD

- Axioms, or rules of inference, provide a simpler technique for reasoning about functional dependencies
- In the rules that follow, we use Greek letters (α, β, γ,...) for sets of attributes.
- We can use the following three rules to find logically implied functional dependencies.
- By applying these rules repeatedly, we can find all of F+, given F. This collection of rules called Armstrong's Axioms in honor of the person who first proposed it.

1. Reflexivity Rule: If α is a set of attributes and $\beta \subseteq \alpha$, then $\alpha \rightarrow \beta$ holds.
2. Augmentation rule: If $\alpha \rightarrow \beta$ holds and γ is a set of attributes, then $\gamma\alpha \rightarrow \gamma\beta$ holds.
3. Transitivity Rule: If $\alpha \rightarrow \beta$ holds and $\beta \rightarrow \gamma$, then $\alpha \rightarrow \gamma$ holds.

① Reflexive

$\alpha \rightarrow \beta$ is Trivial (Reflexive) iff $\alpha \supseteq \beta$

② Augmentation

$\alpha \rightarrow \beta \Rightarrow \alpha\gamma \rightarrow \beta\gamma$

③ Transitive

If $\alpha \rightarrow \beta$ & $\beta \rightarrow \gamma$ then $\alpha \rightarrow \gamma$

Additional Rules

- If $\alpha \to \beta$ holds and $\alpha \to \gamma$ holds, then $\alpha \to \beta\gamma$ holds (union)
- If $\alpha \to \beta\gamma$ holds, then $\alpha \to \beta$ holds and $\alpha \to \gamma$ holds (decomposition)
- If $\alpha \to \beta$ holds and $\gamma\beta \to \delta$ holds, then $\alpha\gamma \to \delta$ holds (Pseudo transitivity)

The above rules can be inferred from Armstrong's Axioms.

$\alpha \to \beta \quad \gamma\beta \to \delta$

Union

If $\alpha \to \beta$, $\alpha \to \gamma$ then $\alpha \to \beta\gamma$

Decomposition

If $\alpha \to \beta\gamma$ then $\alpha \to \beta$ & $\alpha \to \gamma$

But $AB \to C$

$A \to C$ ✗

$B \to C$ ✗

eg

A	B	C
1	2	3
2	1	5
3	1	6
3	1	6
3	2	4

$AB \to C$ ✓

$A \to C$ ✗

$B \to C$ ✗

Armstrong's Axioms/Inference Rules

Inference rules that can be used to infer new dependencies from a given set of dependencies

- IR1 (reflexive rule) : If $X \supseteq Y$, then $X \rightarrow Y$. Trivial
- IR2 (augmentation rule)[2]: $\{X \rightarrow Y\} \models XZ \rightarrow YZ$.
- IR3 (transitive rule): $\{X \rightarrow Y, Y \rightarrow Z\} \models X \rightarrow Z$.
- IR4 (decomposition, or projective, rule): $\{X \rightarrow YZ] \models X \rightarrow Y$, $X \rightarrow Z$
- IR5 (union, or additive, rule): $\{X \rightarrow Y, X \rightarrow Z] \models X \rightarrow YZ$.
- IR6 (pseudotransitive rule): $\{X \rightarrow Y, WY \rightarrow Z| \models WX \rightarrow Z$.

Attribute closure $[X]^+$

Let X be the Attribute Set of Relation R.

Set of ALL possible Attributes which are Logically / functionally determine by X is Called Attribute Closure of X. $[X]^+$.

Attribute closure $[X]^+$

$R(ABCDE)\quad [A \to B,\ B \to C,\ C \to D,\ D \to E]$

$[A]^+ = [ABCDE]$

$[B]^+ = [BCDE]$

$[C]^+ = [CDE]$

$[D]^+ = [DE]$

$[E]^+ = [E]$

Example

Let us consider a relation with attributes A, B, C, D, E, and F. Suppose that this relation has the FD's $AB \rightarrow C$, $BC \rightarrow AD$, $D \rightarrow E$, and $CF \rightarrow B$.

What is the closure of $\{A, B\}$, that is, $\{A, B\}^+$?

$R(ABCDEF)$ $[AB \rightarrow C,\ BC \rightarrow AD,\ D \rightarrow E,\ CF \rightarrow B]$

$[AB]^+ = [ABCDE]$ Ans

Q.

$F = \{Ssn \rightarrow Ename,$

$Pnumber \rightarrow (Pname, Plocation),$

$\{Ssn, Pnumber\} \rightarrow Hours\}$

Find

$\{Ssn\}^+$ = [Ssn Ename]

$\{Pnumber\}^+$ = [Pnumber Pname Plocation]

$\{Ssn, Pnumber\}^+$ = [Ssn Pumber Ename Pname Plocation Hours]

BC

CB

Q.

R (ABCDEFG)

F : (AB → C, BC → AD, D → E, E → G, CE → B)

Find closure of ...

(i) $[A] = [A]$

(ii) $[B]^+ = [B]$

(iii) $[C]^+ = [C]$

(iv) $[D]^+ = [DEG]$

(v) $[E]^+ = [EG]$

(vi) $[F]^+ = [F]$

(vii) $[G]^+ = [G]$

(8) $[ACE]^+ = [ACEGBD]$

(9) $[BDE]^+ = [BDEG]$

(10) $[AB]^+ = [ABCDEG]$

(11) $[BD]^+ = [BDEG]$

(12) $[CE]^+ = [CEBGAD]$

(13) $[BC]^+ = [BCADEG]$

Q. The following functional dependencies are given

$\{PQ \rightarrow RS, PU \rightarrow S, ST \rightarrow U, R \rightarrow V, U \rightarrow T, V \rightarrow P\}$

Which of the following option (s) is/are true ?

[MSQ]

(A) $\{RU\}^+ = \{PRSTUV\}$

(B) $\{PU\}^+ = \{PRSTUV\}$

(C) $\{QV\}^+ = \{PQRSV\}$

(D) $(PQ)^+ = \{PQRSUV\}$

[HOMEWORK]

Ans (A & C).

Q.

The following functional dependencies are given:

$AB \to CD,\ AF \to D,\ DE \to F,\ C \to G,\ F \to E,\ G \to A.$

Which one of the following options is false? [2006: 2 Marks]

PSU: 3 Marks

True (A) $\{CF\}^+ = \{ACDEFG\}$ $[CF]^+ = [CFGEAD] \Rightarrow [ACDEFG]$

True (B) $\{BG\}^+ = \{ABCDG\}$ $[BG]^+ = [BGACD]$

False (C) $\{AF\}^+ = \{ACDEFG\}$ $(AF)^+ = [AFDE]$

False (D) $(AB)^+ = \{ABCDFG\}$ $(AB)^+ = [ABCDG]$

(a) Only (ii)

(b) Only (iv)

(c) (iii) & (iv)

(d) (ii) & (iii)

Keys Concept

SUPER-KEY : Let R be the Relation Schema & X be the Attribute Set of Relation R.

If $[X]^+$ [Closure of X] determines ALL ATTRIBUTES of Relation R then X is Super Key.

OR

- If ALL Attribute of Relation R is determined by the Attribute closure of X $[X]^+$ then X is a Super key.

General Term

Technical

DBMS

Key $\equiv$ Super key

Keys Concept

eg1 $R(ABCDE)$ $[A \to B,\ B \to C,\ C \to D,\ D \to E]$

$[A]^+ = [ABCDE]$

$[B]^+ = [BCDE]$

$[C]^+ = [CDE]$

$[D]^+ = [DE]$

$[E]^+ = [E]$

A is Super key.

Any Super set of super key (A) is also super key.

A

AB

AC

ABC

ABCDE } Super key.

Keys Concept

eg2) R(ABCDE) [AB→C , C→D , D→E]

$(AB)^+ = [ABCDE]$

× $(A)^+ = [A]$

× $(B)^+ = [B]$

$\boxed{\text{AB is Super key.}}$ ✓

AB is Super key
then Any Super Set of Super key [AB] is also Super key

AB
AB C
AB D
AB CD
⋮
AB CDE

Super key

Keys Concept

Note

Every key is Super key.

Note

Any Super Set of Super key is also Super key.

Keys Concept

Super key $\xrightarrow{\text{Minimal}}$ Candidate key [C.K]

Candidate key [C.K] $\xrightarrow{\text{1 select as}}$ Primary key

Candidate key [C.K] $\xrightarrow[\text{Except Primary key}]{\text{Remaining C.K}}$ Alternative/secondary key.

Any Doubt ?

THANK YOU!