COMPUTER SCIENCE

Database Management System

FD's & Normalization

Lecture_02

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TOPICS TO BE COVERED

01 Attribute Closure

02 Finding Candidate keys

- RDBMS Concept
  - ↳ Arity, Cardinality, Schema, instance
    Relational
- FD Concepts
- Type of FD
  1. Trivial FD
  2. Non Trivial FD
  3. semi Non Trivial FD.

Q) Finding Non Trivial FD which is Satisfied by Given Relational Instance ?

Q.5

A	B	C
7	5	6
7	7	6
7	5	7
7	7	7
9	5	6

Trivial FD Always valid

$A \rightarrow A$

$\boxed{AB \rightarrow A}$

$AB \rightarrow B$

$AB \rightarrow AB$

None. Ans

$A \rightarrow B$ | $B \rightarrow A$ | $C \rightarrow A$ | $AB \rightarrow C$

$A \rightarrow C$ | $B \rightarrow C$ | $C \rightarrow B$ | $BC \rightarrow A$

$A \rightarrow BC$ | $B \rightarrow AC$ | $C \rightarrow AB$ | $AC \rightarrow B$

Q.6

A	B	C
2	2	4
2	3	4
3	2	4
3	3	4
3	2	4

$\boxed{\begin{array}{c} A \rightarrow C \\ B \rightarrow C \\ AB \rightarrow C \end{array}}$ Ans

$A \rightarrow B$ $B \rightarrow A$ $C \rightarrow A$ $AB \rightarrow C$

$A \rightarrow C$ $B \rightarrow C$ $C \rightarrow B$ $BC \rightarrow A$

$A \rightarrow BC$ $B \rightarrow AC$ $C \rightarrow AB$ $AC \rightarrow B$.

Q.7

Given the following relation instance.

X	Y	Z
4	4	4
4	7	4
7	4	7
7	4	9
4	9	9

$\boxed{YZ \to X}$ Ans

The number of non trivial FD's are satisfied by the instance ___

$X \to Y$ $\quad Y \to X$ $\quad Z \to X$ $\quad XY \to Z$

$X \to Z$ $\quad Y \to Z$ $\quad Z \to Y$ $\quad YZ \to X$

$X \to YZ$ $\quad Y \to XZ$ $\quad Z \to XY$ $\quad XZ \to Y$

⋮

Q.8 Given the following relation instance. [2000: 2 Marks]

X	Y	Z
1	4	2
1	5	3
1	6	3
3	2	2

Which of the following functional dependencies are satisfied by the instance?

Ans (B)

(A) $XY \rightarrow Z$ and $Z \rightarrow Y$

(B) $YZ \rightarrow X$ and $Y \rightarrow Z$

(C) $YZ \rightarrow X$ and $X \rightarrow Z$

(D) $XZ \rightarrow Y$ and $Y \rightarrow X$

Q.9 From the following instance of a relation scheme R (A, B, C), we can conclude that: [2002: 2 Marks]

A	B	C
1	1	1
1	1	0
2	3	2
2	3	2

Ans (C)

(A) A functionally determines B and B functionally determines C

(B) A functionally determines B and B does not functionally determines C

(C) B does not functionally determines C

(D) A does not functionally determines B and B does not functionally determines C

Conclude that:

1. Rule out the FD Based on the Table Instance

2. Trivial FD are Always Valid.

$\Downarrow$

$A \to A$ ✓

$AB \to A$ ✓

$AB \to AB$

$AB \to B$

$BC \to B$

$BC \to B$

$BC \to BC$

Q.10

Consider the relation X(P, Q, R, S, T, U) with the following set of functional dependencies [2015: 1 Marks]

$F = \{$

$\{P, R\} \rightarrow \{S, T\}$

$\{P, S, U\} \rightarrow \{Q, R\}$

$\}$

$\boxed{X \supseteq y}$

$AB \rightarrow A$
$AB \rightarrow B$
$AB \rightarrow AB$

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

Non Trivial

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

semi N-T $\quad x \not\supseteq y \;\&\; x \cap y \neq 0$

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

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

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

N.T.

(a) CC with Enjoying Chemical Concept

(b) CC

(c) C

(d) Doubt

Armstrong's Axioms/Inference Rules

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

Additional Rules

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

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

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 $X \rightarrow Y$.
- IR2 (augmentation rule)^2: $\{X \rightarrow Y\} \mid= XZ \rightarrow YZ$.
- IR3 (transitive rule): $\{X \rightarrow Y, Y \rightarrow Z\} \mid= X \rightarrow Z$.
- IR4 (decomposition, or projective, rule): $\{X \rightarrow YZ] \mid= X \rightarrow Y$.
- IR5 (union, or additive, rule): $\{X \rightarrow Y, X \rightarrow Z] \mid= X \rightarrow YZ$.
- IR6 (pseudotransitive rule): $\{X \rightarrow Y, WY \rightarrow Z| \mid= WX \rightarrow Z$.

Attribute closure $[X]^+$

Attribute closure $[X]^+$: Let R be the Relational Schema
X be the attribute set of Relation R,

Set of ALL Possible Attributes which is Logically determined by Attribute X is Called Attribute closure of X. $[X]^+$.

$R(ABCDEF) \quad \{A \to B,\ B \to C,\ C \to D,\ D \to E,\ E \to F\}$

$(A)^+ = \{ABCDEF\}$

$(B)^+ = \{BCDEF\}$

$(C)^+ = \{CDEF\}$

$(D)^+ = \{DEF\}$

$(E)^+ = \{EF\}$

$(F)^+ = \{F\}$

$(BE)^+ = \{BECDF\}$

$(AD)^+ = \{ADBCEF\}$

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→C, BC→AD, D→E, CF→B]

$(AB)^{+} = [ABCDE]$

Q.

$F = \{Ssn \rightarrow Ename,$

$Pnumber \rightarrow (Pname, Plocation),$

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

Find

1. $\{Ssn\}^+$ = [Ssn Ename]
2. $\{Pnumber\}^+$ = [Pnumber Pname Plocation)
3. $\{Ssn, Pnumber\}^+$ = [Ssn Pnumber Hours Ename Pname Plocation]

Q.

R (ABCDEG)

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

Find closure of ...

$[A]^+ = [A]$

$[B]^+ = [B]$

$[C]^+ = [C]$

$[D]^+ = [DEG]$

$[E]^+ = [EG]$

$[G]^+ = [G]$

$[AB]^+ = [ABCDEG]$

$[AD]^+ = [ADEG]$

$[AE]^+ = [AEG]$

$[ACE]^+ = [ACEGBD]$

$[ABCDEG]$

$[ABE]^+ = [ABCDEG]$

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) $\{RU\}^+ = \{PRSTUV\}$ $[RU]^+ = [RUVTPS] \Rightarrow [PRSTUV]$

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

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

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

$\boxed{\text{Ans (A) \& (C).}}$

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]

ISRO : 2015.

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

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

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

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

$\boxed{\text{(iii) \& (iv) are False}}$

Keys Concept

SUPER KEY :

Let R be the Relational Schema & X be the attribute set of Relation R,

If all Attributes of Relation R is determined Attribute closure of X, $[X]^+$

then X is a super key

OR

If $(X)^+$ [closure of X] determined All Attribute of Relational Schema R,

then X is a super key.

Keys Concept

SUPER KEY

R(ABCDEF) {A→B, B→C, C→D, D→E, E→F}

Soln

$\boxed{[A]^+ = [ABCDEF]}$

A is Super key.

$(B)^+ = (BCDEF)$

Any superset of Super key is also super key.

$(C)^+ = (CDEF)$

$(D)^+ = (DEF)$

$(E)^+ = (EF)$

$(F)^+ = (F)$

AB   ABC   :   ABCDEF
AC   ADE   :
AD   AF
...

Super key

Keys Concept

SUPER KEY

Note

Any super set of super key is also super key.

Keys Concept

SUPER KEY

[Assume 6 C.K]

SUPER KEY $\xrightarrow{\text{Minimal}}$ **Candidate Key** [C.K]

Candidate Key: 1 Select as → Primary key

Remaining C.K Except Primary Key → Alternative/ Secondary key

5 → A.K

Keys Concept

Candidate key :

Minimal of Super key.

OR

If Any Proper Subset of Super key is also Super key then that Proper subset is called Candidate key [& so on] eg $R(ABCDE)$ $[AB \to C, C \to D, B \to EA]$

$(AB)^+ = (ABCDE)$

AB is Super key

$\boxed{AB}$

Proper subset

A B

$(A)^+ = (A)$

$(B)^+ = (BEACD)$

B is Candidate key

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eg $R(ABCDE)$ $[AB \to C, C \to D, B \to E]$

$(AB)^+ = (ABCDE)$

AB is Super key.

AB

Proper subset

A B

$(A)^+ = (A)$

$(B)^+ = (BE)$

AB is Candidate key.

Keys Concept

AB is Condidate key

A B

✗ ✗

AB
BC
AC
A
B
C

ABC is C.K

Any Doubt ?

THANK YOU!