

Computer Science & IT

Database Management System

Relational Model & Normal Forms

Lecture No. 03



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Recap of Previous Lecture



Topic

Introduction Relational Database Model



Topic

Functional dependency

Topics to be Covered



- ★ **Topic** Properties of functional dependency
- ★ **Topic** Different types of keys in RDBMS
 - ★ **Topic** Candidate key
 - ★ **Topic** Super key

Consider the following relational instance

A	B	C
1	1	1
1	1	2
2	1	2
2	2	3
3	3	4

Possible non-trivial FDs w.r.t. three attributes 'A', 'B' & 'C'

$X_A \rightarrow B$	$X_A \rightarrow BC$	$X_{AB} \rightarrow C$
$X_A \rightarrow C$	$X_B \rightarrow AC$	$AC \rightarrow B$
$X_B \rightarrow A$	$X_C \rightarrow AB$	$X_{BC} \rightarrow A$
$X_B \rightarrow C$		
$X_C \rightarrow A$		
$C \rightarrow B$		

Find all non-trivial FDs which may hold true in the above relation based on given relational instance.

$$\underline{\underline{Ans}}: C \rightarrow B, AC \rightarrow B$$

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FD $X \rightarrow Y$ is called an useful FD if and only if both X and Y are non-empty sets and $X \cap Y = \emptyset$

it is the
definition
of non-trivial
FD

How many useful FDs are possible in a relation
with '4' attributes ?

Q:- How many non-trivial FDs are possible in a relation
 ↓ with "4" attributes let attributes are A, B, C & D

(Some as
Previous
question)

$A \rightarrow B$	$C \rightarrow A$	$A \rightarrow BC$	$C \rightarrow AB$	$A \rightarrow BCD$
$A \rightarrow C$	$C \rightarrow B$	$A \rightarrow BD$	$C \rightarrow AD$	$B \rightarrow ACD$
$A \rightarrow D$	$C \rightarrow D$	$A \rightarrow CD$	$C \rightarrow BD$	$C \rightarrow ABD$
$B \rightarrow A$	$D \rightarrow A$	$B \rightarrow AC$	$D \rightarrow AB$	$D \rightarrow ABC$
$B \rightarrow C$	$D \rightarrow B$	$B \rightarrow AD$	$D \rightarrow AC$	
$B \rightarrow D$	$D \rightarrow C$	$B \rightarrow CD$	$D \rightarrow BC$	

↓ 28 FDs

$AB \rightarrow C$	$AB \rightarrow CD$
$AB \rightarrow D$	$AC \rightarrow BD$
$AC \rightarrow B$	$AD \rightarrow BC$
$AC \rightarrow D$	$BC \rightarrow AD$
$AD \rightarrow B$	$BD \rightarrow AC$
$AD \rightarrow C$	$CD \rightarrow AB$
$BC \rightarrow A$	
$BC \rightarrow D$	
$BD \rightarrow A$	
$BD \rightarrow C$	
$CD \rightarrow A$	
$CD \rightarrow B$	

↓ 18 FDs

$ABC \rightarrow D$
$ACD \rightarrow B$
$ABD \rightarrow C$
$BCD \rightarrow A$

↓ 4 FDs

Total no. of FDs = $28 + 18 + 4 = 50$

Q:- How many non-trivial FDs are possible in a relation
with "4" attributes (Let attributes are A, B, C, & D)

(Some as
previous
question)

Relation contains 4 attributes, \therefore In any non-trivial FD $X \rightarrow Y$
we know $1 \leq |X| \leq 3$

Case ① When $|X| = 1$, then $|Y| = 1$ or 2 or 3

$$X \longrightarrow Y$$
$$4_{C_1} \text{ and } (3_{C_1} \text{ or } 3_{C_2} \text{ or } 3_{C_3}) = 4_{C_1} * (3_{C_1} + 3_{C_2} + 3_{C_3}) = 4 * (3+3+1) = 28$$

Case ② When $|X| = 2$, then $|Y| = 1$ or 2

$$X \longrightarrow Y$$
$$4_{C_2} * (2_{C_1} + 2_{C_2}) = 6 * (2+1) = 6 * 3 = 18$$

Case ③ When $|X| = 3$ then $|Y| = 1$

$$X \longrightarrow Y$$
$$4_{C_3} * (1_{C_1}) = 4 * 1 = 4$$

Total no.
of FDs = $28 + 18 + 4 = 50$

Q: Let $R(A B C D E)$ be the relational schema.
 How many non-trivial FDs can be defined in relation R
 wrt. non-trivial FD $X \rightarrow Y$

Case ① When $|X|=1 \left\{ 5_{C_1} * (2^4 - 1) \right\} = 5 * 15 = 75$

Case ② When $|X|=2 \left\{ 5_{C_2} * (2^3 - 1) \right\} = 10 * 7 = 70$

Case ③ When $|X|=3 \left\{ 5_{C_3} * (2^2 - 1) \right\} = 10 * 3 = 30$

Case ④ When $|X|=4 \left\{ 5_{C_4} * (2^1 - 1) \right\} = 5 * 1 = 5$

Total no. of FDs = $75 + 70 + 30 + 5 = 180$

Topic : Properties of Functional Dependencies

① Reflexivity : \rightarrow FD $X \rightarrow Y$ is called a reflexive FD
only if $X \supseteq Y$

Every Reflexive FD will always hold true in relation

② Augmentation : \rightarrow Let FD $X \rightarrow Y$ exist in relation R
then $XZ \rightarrow YZ$ will also hold true in relation R

③ Transitivity : \rightarrow Let $X \rightarrow Y$ and $Y \rightarrow Z$ holds true in relation R

These three properties are
Called "Armstrong's Axioms"



Topic : Properties of Functional Dependencies

④ Decomposition :- (Splitting Rule)

If FD $X \rightarrowYZ$ holds true in relation R
then $X \rightarrow Y$ & $X \rightarrow Z$ will also hold
true in relation R

If $XY \rightarrow Z$ exists
then $X \rightarrow Z$ and
 $Y \rightarrow Z$ need not
hold true in the relation

We can not split
the set at L.H.S.

Let $\overbrace{AB}^{\text{semi-non-trivial FD}} \rightarrow BC$ holds true in relation
then By splitting rule.
 $AB \rightarrow B$ { Trivial Part of $AB \rightarrow BC$ }
& $AB \rightarrow C$ { Non-trivial Part of $AB \rightarrow BC$ }
We can always decompose semi non-trivial FDs
in to two parts (i) Trivial part & (ii) Non-trivial part



Topic : Properties of Functional Dependencies

⑤ Union:- If $X \rightarrow Y$ and $X \rightarrow Z$ holds true in the relation
then " $X \rightarrowYZ$ " will also hold true in relation

⑥ Composition:- If $X \rightarrow Y$ and $P \rightarrow Q$ holds true in relation
then $XP \rightarrow YQ$ will also hold true in relation

⑦ Pseudo Transitivity:- If $X \rightarrow Y$ and $YW \rightarrow Z$ holds true in relation
then $XW \rightarrow YZ$ will also hold true in relation

Key Concept :-

- * In a relational table no two tuples should be exactly same
 - * ↳ i.e., In a relational table duplicate tuples are not allowed
 - * ↳ To implement this restriction every relation must have a key.

"Key" :→ A Key in a relation is the set of attributes that can uniquely identify each tuple in the relation



Topic : Different types of keys



There are various types of Keys

1 Candidate Key

2 Primary Key

3 Alternate Key (Secondary Key)

4 Super Key

5 Foreign Key

"Foreign Key" is not actually a key

- * We will discuss about foreign key during the discussion of ER Model

* Minimal Set : → A set of elements from which no element can be removed without losing the associated property is called a minimal set.

{ I.e., Whenever we remove any element from the set then it is guaranteed that it will lose the associated property.

Note: → If values of a set of attributes are guaranteed to be unique in a relation, then that set of attributes is definitely a "key" of that relation { But it may or may not be minimal }



Topic : Candidate key

A minimal set of attributes that can uniquely identify each tuple of the relation is called a Candidate Key.

- * i.e., A set of attributes from which no attribute can be removed without destroying its property of being a key is called a Candidate key.

Another definition: - A minimal set of attributes that can determine all attributes of the relation is called a Candidate Key.

eg 1 :- Consider the following relation

Student

Sid.	Sname	Fee
S ₁	A	500
S ₂	A	500
S ₃	B	600
S ₄	B	400
S ₅	C	600

Also consider that following functional dependencies holds in the relation

$$\begin{cases} \text{Sid} \rightarrow \text{Sname} \\ \text{Sid} \rightarrow \text{fee} \end{cases}$$

We know {Sid} → Sid holds

$$\begin{array}{c} \text{Augmentation} \\ \text{of} \\ \text{Sname} \\ \text{Sid} \rightarrow \text{Sid, Sname, fee} \\ \text{all attributes} \end{array}$$

∴ Sid is a key (also minimal)

∴ (Sid, Sname) is also a key but it is not minimal, because we can remove Sname from the set

'Sid' is a minimal key

∴ Sid is a Candidate key

eg 2 :- Consider the following relation

Enroll

instructor Id

Sid	Cid	I-id
S ₁	C ₁	101
S ₂	C ₁	101
S ₃	C ₂	101
S ₃	C ₃	102
S ₄	C ₃	102

Consider following functional dependency holds in the relation

$$\begin{cases} \text{Cid} \rightarrow \text{I-id} \end{cases}$$

$$\downarrow$$

$$\text{Cid} \rightarrow \text{Cid, I-id}$$

↓ Augment Sid

$$\{ \text{Sid}, \text{Cid} \} \rightarrow \{ \text{Sid}, \text{Cid}, \text{I-id} \}$$

∴ all attributes
∴ {Sid, Cid} is a key

If we remove 'Cid' from the set, then 'Sid' alone can not uniquely identify each tuple of relation.

i.e. Sid is not a key

Similarly if we remove 'Sid' from the set then Cid alone can not uniquely identify each tuple of relation

i.e. 'Cid' is not a key

∴ We can not remove any attribute from set {Sid, Cid} without losing its property of being a key
Hence {Sid, Cid} is minimal key i.e. a Candidate key



Topic : Candidate key

- ① A key with a single attribute is always minimal, hence a key with a single attribute is always a candidate key.
- ② If a candidate key is formed of a single attribute, then it is called a simple candidate key.
- ③ If a candidate key is formed of two or more attributes, then it is called Compound or Composite Candidate key.



Topic : Candidate key

- ④ A relation may have more than one candidate key.
{ Number of candidate keys in a relation will be identified by functional dependencies that holds true in the given relation }
- ⑤ Attribute that belongs to any of the candidate key is called "Prime attribute" (or key attribute)
- ⑥ Attribute that does not belong to any candidate key of relation is called "Non-prime attribute" (or non-key attribute)



2 mins Summary



Topic

Properties of functional dependency

Topic

Different types of keys in RDBMS

Topic

Candidate key

Topic

Super key



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THANK - YOU