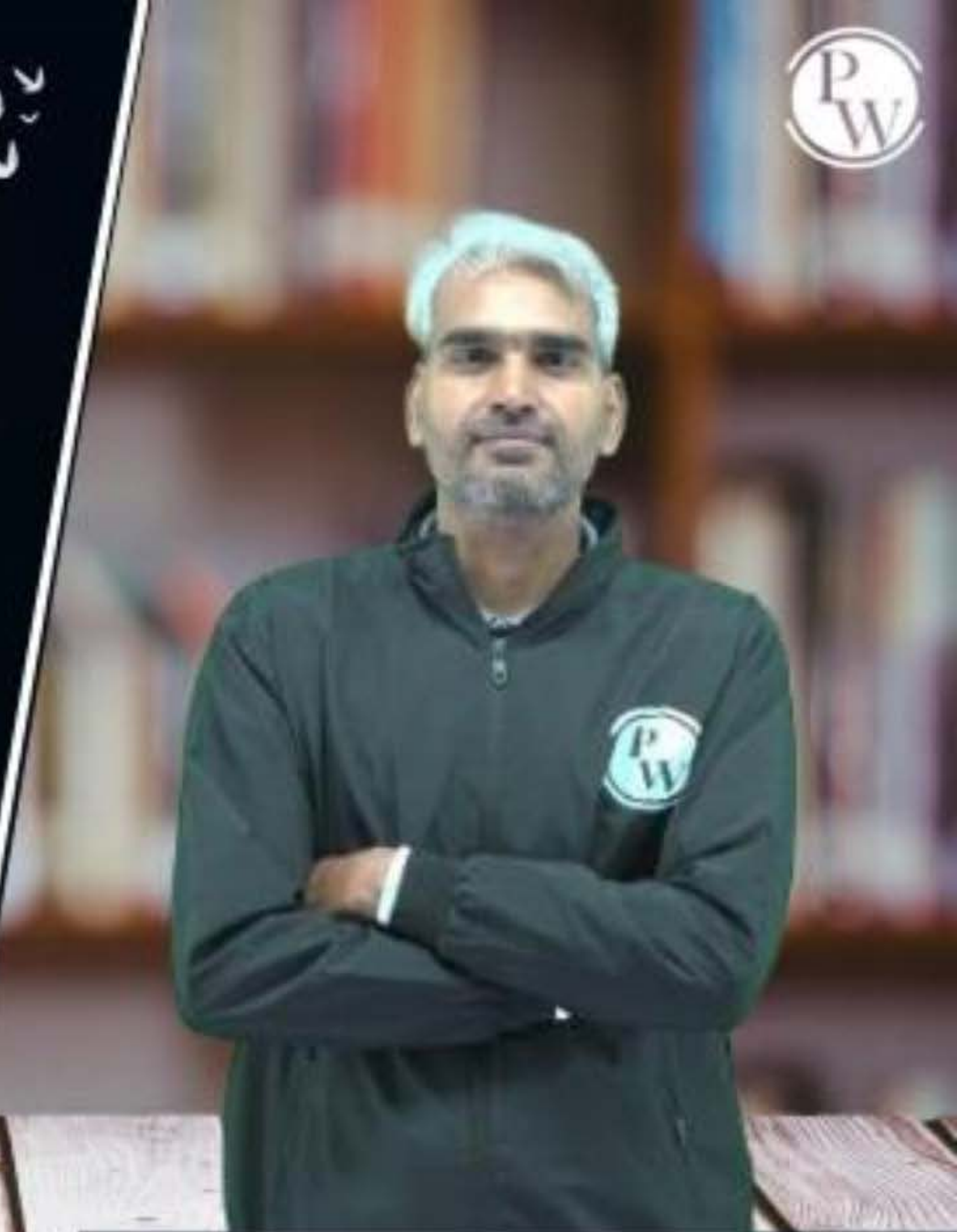
Computer Science & IT

Database Management System

Relational Model & Normal Forms

Lecture No. 04



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Recap of Previous Lecture

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

[redacted]

Topics to be Covered

- **Topic** Candidate key
- **Topic** Super key
- **Topic** Closure of attribute set

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. $\boxed{\text{Foreign key}}$

"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 <u>guaranteed</u> 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 <u>minimal set</u> 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.

eg①:- 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

{ Sid → Sname
Sid → fee }

we know Sid → Sid holds

⇓ Union

Sid → $\underbrace{\text{Sid, Sname, fee}}_{\text{all attributes}}$

∴ Sid is a key (also minimal)

Augmentation of Sname

{Sid, Sname} → $\underbrace{\text{\{Sid, Sname, fee\}}}_{\text{all attributes}}$

∴ (Sid, Sname) is also a key

but it is not minimal, because we can remove Sname from the set

$\boxed{\text{"Sid" is a minimal key ∴ Sid is a Candidate key}}$

eg②: Consider the following relation

Enroll

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

instructor Id

Consider following functional dependency holds in the relation

{ Cid → I-id }

⇓

Cid → Cid, I-id

⇓ Augment Sid

{Sid, Cid} → $\underbrace{\text{\{Sid, Cid, I-id\}}}_{\text{all attributes}}$

∴ {Sid, Cid} is a key

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

⟹ i.e. 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) Attribut that does not belong to any Candidate key of relation is called "non-prime attribute" (or non-key attribute)

Primary Key: A relation may have more than one candidate keys, and one of those candidate keys may be chosen as Primary Key.

Not necessary

* A relation can have at most one Primary Key.

* Attributes belonging to primary key are not allowed to take the NULL values.

Alternate Key (Secondary Key) :- All candidate Keys Except the Primary key are called alternate key

Topic : Super key

Need not be minimal

A set of attributes that can uniquely identify each tuple in the relation is called a super key. {Super key need not be minimal}

(or)

{ A set of attributes (need not be minimal) that can determine all attributes of the relation is called a super key.

* Every Candidate key is also a Super key, but Every Super key need not be a Candidate key.

Note:- ① Any superset of a Candidate key is a super key.

② At least one subset of Every Super Key is a Candidate key

③ Super key = {Take all attributes of one Candidate key + 0 or more attributes out of remaining attributes}

eg:- Consider the following relational schema
Student (Sid, Sname, Branch)
If "Sid" is the only Candidate key of the relation Student, then identify the total number of super keys in relation Student.

* Every Superset of Candidate Key is a Super Key

$${}^2C_0 + {}^2C_1 + {}^2C_2 = 2^2 = 4$$

$\{\underset{CK}{Sid}\}$ ← C.K + 0 out of remaining '2' attributes → $\boxed{{}^2C_0 = 1}$

∴ Super keys of relation =
$\{\underset{CK}{Sid}, Sname\}$, $\{\underset{CK}{Sid}, Branch\}$ ← C.K + 1 out of remaing '2' attributes → $\boxed{{}^2C_1 = 2}$

$\{\underset{CK}{Sid}, Sname, Branch\}$ Ck + '2' out of remaining '2' attributes ← $\boxed{{}^2C_2 = 1}$

Topic : Closure of an attribute set

- Closure of an attribute set X (i.e., X^+) can be defined as a set of all the attributes that can be functionally determined from attributes of set X.

#e.g. Consider the following FD set

$F = \{ AB \rightarrow CD, AF \rightarrow D, DE \rightarrow F, C \rightarrow G, F \rightarrow E, G \rightarrow A\}$

find the closure of following set of attributes.

(i) $\{C,F\}$ $\{CF\}^+ = \{C, F, G, E, A, D\}$

(ii) $\{B,G\}$ $\{BG\}^+ = \{B, G, A, C, D\}$

(iii) $\{A,F\}$ $\{AF\}^+ = \{A, F, D, E\}$

(iv) $\{A,B\}$ $\{AB\}^+ = \{A, B, C, D, G\}$

#e.g. Assume a relation R (A,B,C,D) that has the following functional dependencies:

A→B

B→C

C→D

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

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

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

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

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

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

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

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

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

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

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

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

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

$(CD)^+ = \{C, D\}$

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

Topic : Super key

Let R be the relational schema, and let X be some set of attributes over relation R. If X^+ Contains all attributes of relation R, then X is called super key of relation R.

#e.g. Assume a relation R (A,B,C,D) that has the following functional dependencies:

A→B

B→C

C→D

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

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

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

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

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

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

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

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

Closure of following sets of attributes contains all attributes of relation

↳ ∴ All are Superkey of relation R.

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

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

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

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

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

$(CD)^+ = \{C, D\}$

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

Proper subset :- For a given set A, any subset of set A, except set A itself is a Proper subset of set A.

eg. let $A = \{a, b, c\}$

All subsets of set A are $= \{\ \}, \{a\}, \{b\}, \{c\}, \{a, b\}, \{a, c\}, \{b, c\}, \{a, b, c\}$

Proper Subsets of A $= \{\ \}, \{a\}, \{b\}, \{c\}, \{a, b\}, \{a, c\}, \{b, c\}$

× Not allowed in Proper subset

Let $\{A, B, C\}$ is a Super key of relation R

i.e., $\{A, B, C\}^+ =$ All attributes of relation R

Non-Empty Proper subsets of $\{A, B, C\}$ are = $\underbrace{\{A\} \quad \{B\} \quad \{C\} \quad \{A,B\} \quad \{A,C\}, \quad \{B,C\}}$

If none of these Proper subsets of $\{A, B, C\}$ is a Super key of relⁿ R, then $\{A, B, C\}$ is a minimal Super key of relⁿ R i.e. $\{A, B, C\}$ is a C.K of R

If at least one of these proper subsets of $\{A, B, C\}$ is a Super key then it means $\{A, B, C\}$ is not a minimal Superkey i.e. Not a Candidate key

Topic : Candidate key (Minimal Super key)

Let R be the relational schema, and let X be the super key of relation R.

If no proper subset of X is a super key thenX is minimal super key i.e., X is Candidate key

if any proper subset of X is a S.K.
then 'X' is not minimal.

Hence X is just a Super key, but not a Candidate key

#Q. Assume a relation R (A, B, C, D, E) that has the following functional dependencies:

$$F = \begin{cases} AB \to C, \\ B \to E, \\ C \to D \end{cases}$$

Find the Candidate key of R.

Note:- Attributes that are not Present in RHS part of any of the FD of given set of FDs are called "Essential attributes"

Every Essential attribute must be Present in Every key of relⁿ

- A & B are Essential attributes

$$(AB)^+ = \{\underbrace{A, B, \boxed{C, D, E}}_{\text{all attributes of Rel}^n}\}$$

∴ (AB) is a Super Key

Both A & B are Essential, ∴ None can be removed from the key

Hence, $\boxed{AB}$ is a C.K

Check for Candidate Key

Proper Subsets of {A,B}

$\{A\}^+ = \{A\}$ Not all attributes ∴ A is not a S.K

$\{B\}^+ = \{B, E\}$ Not all attributes ∴ B is not a S.K

No proper subset of {A,B} is a Super key

∴ (AB) is a minimal Super key

Hence $\boxed{AB}$ is a C.K.

In the above example $\boxed{AB}$ is a Candidate Key

∴ Prime Attributes = {A, B}

If there is no FD in the set of FDs that that contain any of the prime attributes in its R.H.S. part, then that relation will have only one candidate Key

Current Prime attributes are A & B,

No FD in the FD set contain A or B in its RHS part

∴ Relation will have only one Candidate Key

i.e, $\boxed{AB}$ is the only Candidate Key of relation

And Prime Attributes = {A, B}

Non-Prime Attributes = {C, D, E}

H.W.

#Q. Assume a relation R (A, B, C, D, E) that has the following functional dependencies:

$AB \rightarrow C$,

$B \rightarrow E$,

$C \rightarrow D$

$E \rightarrow A$

Find the Candidate key of R.

2 mins Summary

Topic Candidate key

Topic Super key

Topic Closure of attribute set

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THANK - YOU

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