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Normalization: Part II

Complete Course on Database Management System

Vishvadeep Gothi • Lesson 13 • July 4, 2023

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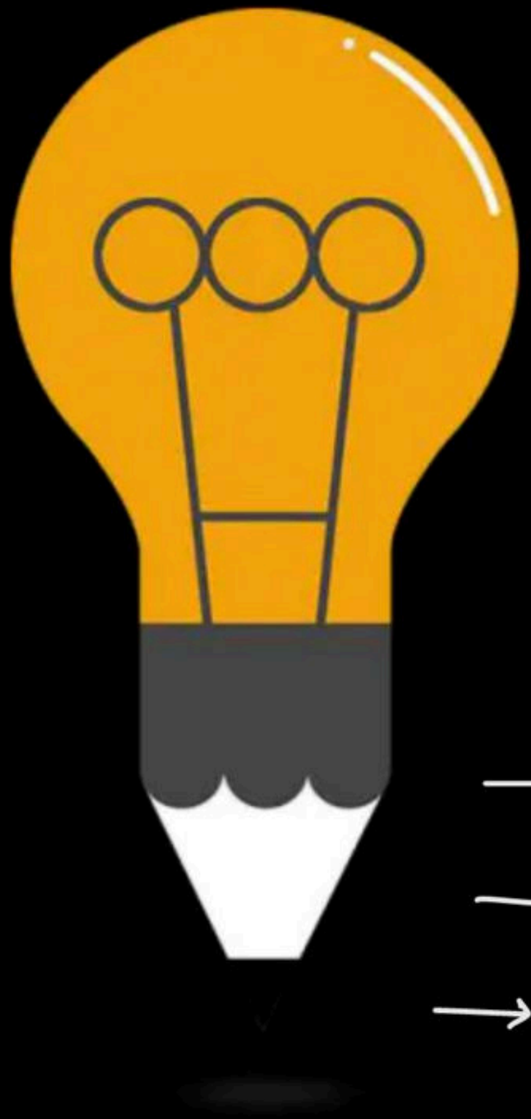
Basics, E-R modeling

SQL



DBMS

Relational DB

By: Vishvadeep Gothi

→ RDBMS Terms

→ F.D.s

→ Normalization

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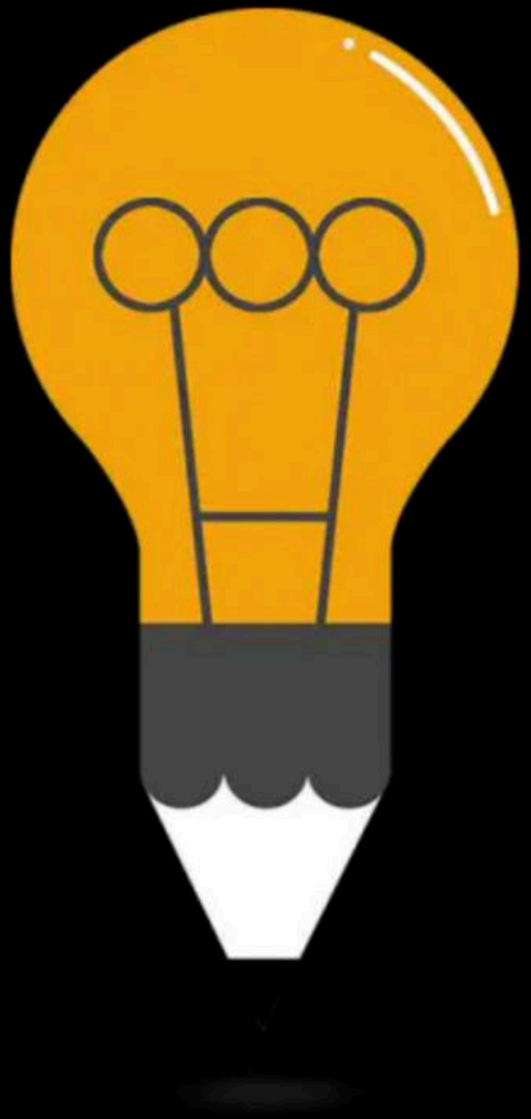

Relational Model

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Relational Model

The relational model uses a collection of tables to represent both data and the relationships among those data

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Relation

The main construct for representing data in the relational model is a relation, which is table.

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Attribute (column, field)

Attributes are used to describe relations

Or

Columns of relations are attributes

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Tuple Or Record / ১০৩

A row in a relation

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Relation Example

The account relation with unordered tuples

account-number	*branch-name*	*balance*
A-101	Downtown	500
A-215	Mianus	700
A-102	Perryridge	400
A-305	Round Hill	350
A-201	Brighton	900
A-222	Redwood	700
A-217	Brighton	750

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Database Schema

Logical design of database

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Database Instance

Snapshot of the data in the database at a given instant in time

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Domain

A unique set of values permitted for an attribute

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Domain Constraint

Specifies an important condition that we want each instance of relation to satisfy

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Degree or Arity

Number of attributes in relation

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Cardinality

Number of tuples in a relation

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Relational Database

A relational database is a collection of relations

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Keys

An attribute or set of attributes whose values can uniquely identify a tuple in a relation

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Keys

1. Super Key
2. Candidate Key
3. Primary Key
4. Alternate Key
5. Foreign Key

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Functional Dependency

Consider a relation R and 2 attributes A and B in R.

B is functionally dependent on A (denoted by A → B), if each value of A is associated with exactly one value in B in relation R.

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Functional Dependency

Consider a relation R and 2 attributes A and B in R.

B is functionally dependent on A (denoted by A → B), if each value of A is associated with exactly one value in B in relation R.

A	B	C	D
a_1	b_1	c_1	d_1
a_1	b_2	c_1	d_2
a_2	b_2	c_2	d_2
a_2	b_2	c_2	d_3
a_3	b_3	c_2	d_4

check $A \rightarrow B$ ✗ doesn't hold

$A \rightarrow C$ ✓ holds

$B \rightarrow C$ ✗

$D \rightarrow A$ ✗

$C \rightarrow A$ ✗

$AB \rightarrow C$ ✓ holds

$AC \rightarrow D$ ✗

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Functional Dependency: Example

A	B	C
10	B1	1
10	B2	2
11	B4	1
12	B3	4
13	B1	1
14	B3	4

$A \rightarrow B$ ✗

$B \rightarrow A$ ✗

$B \rightarrow C$ ✓

$C \rightarrow A$ ✗

$C \rightarrow B$ ✗

$A \rightarrow C$ ✗

$AB \rightarrow C$ ✓

$AC \rightarrow B$ ✓

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Functional Dependency

- Functional dependencies play a key role in differentiating good database designs from bad database designs
- A functional dependency is a type of constraint that is a generalization of the notion of key
- X → Y, where X is a set of attributes that can determine the value of Y

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Closure of an Attribute

what all attributes we can derive from given attribute

exc:-

$R(A, B, C)$

$FD = \{B \rightarrow C\}$

closure of $A = A^+ = \{A\}$

$B^+ = \{B, C\}$

$C^+ = \{C\}$

Ques) $R(A, B, C, D)$

$FD = \{ A \to B,$
$C \to D \}$

$A^+ = \{A, B\}$

$B^+ = \{B\}$

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

$D^+ = \{D\}$

Ques) $R(A, B, C, D)$

$FD = \{ A \to B,$
$C \to D,$
$D \to A \}$

$A^+ = \{A, B\}$

$B^+ = \{B\}$

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

$D^+ = \{D, A, B\}$

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Trivial Functional Dependency

Some functional dependencies are said to be trivial because they are satisfied by all relations

$A \rightarrow A$

$B \rightarrow B$

$C \rightarrow C$

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Armstrong's Axioms

1. Reflexivity Rule
2. Augmentation Rule
3. Transitivity Rule

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Reflexivity Rule

A functional dependency $\alpha \rightarrow \beta$ holds, If $\beta \subseteq \alpha$

where α, β are attributes or set of attributes in a relation R

$AB \rightarrow B$ ✓

$AC \rightarrow C$ ✓

$AC \rightarrow A$ ✓

$AB \rightarrow A$ ✓

} Trivial dependencies

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Augmentation Rule

A functional dependency α →β holds, then γα → γβ also holds where α, β and γ are attributes or set of attributes in a relation R

if $A \rightarrow B$ holds then

$AC \rightarrow BC$ holds

---

if $E \rightarrow F$ holds

then $ABE \rightarrow ABF$ also hold

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Transitivity Rule

A functional dependencies α →β and β → γ holds,

then α → γ also holds

where α, β and γ are attributes or set of attributes in a relation R

$A \rightarrow B$ and $B \rightarrow C$ } hold then $A \rightarrow C$ holds

Additional Rule

Union Rule: A functional dependencies α →β and α → γ holds, then α → βγ also holds

where α, β and γ are attributes or set of attributes in a relation R

$A \rightarrow B$ holds
$A \rightarrow C$ holds
} ⟶ $A \rightarrow BC$

if
$A \rightarrow D$
$A \rightarrow E$
$A \rightarrow F$
} hold
⇓
$A \rightarrow DEF$

$D \rightarrow A$

$AB \rightarrow C$

} hold then $DB \rightarrow C$

$AB \rightarrow C$

$E \rightarrow A$

$D \rightarrow B$

} hold

$EB \rightarrow C$

$AD \rightarrow C$

} also hold

$ED \rightarrow C$

Pseudo Transitivity Rules

$AB \rightarrow C$

$CF \rightarrow A$

} hold then $BEF \rightarrow C$ also holds

Closure of a Set of Functional Dependencies

Ex:-

$R(A, B, C)$

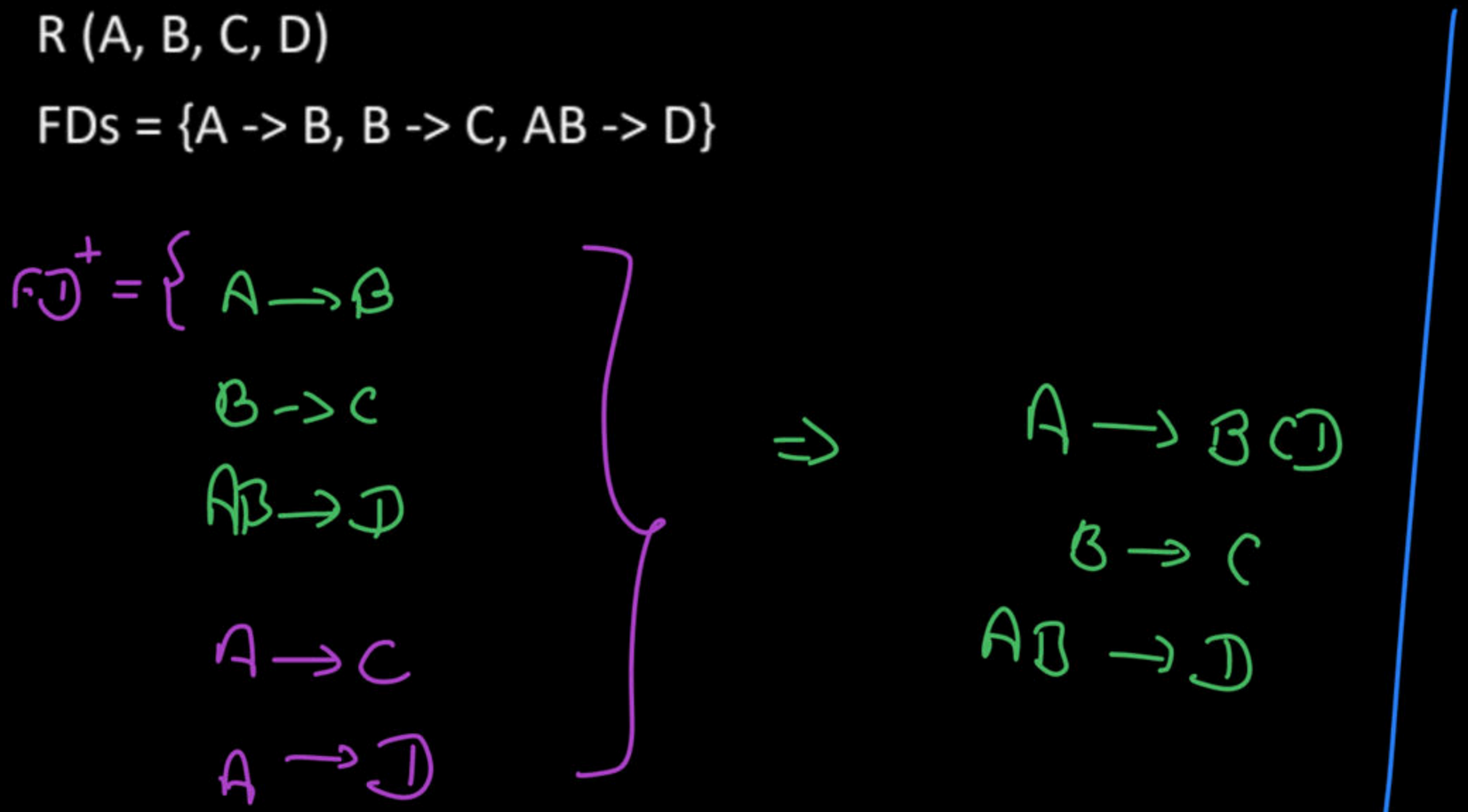
$FD = \{ A \rightarrow C,$
$C \rightarrow B \}$

$FD^+ = \{ A \rightarrow C,$
$C \rightarrow B,$
$A \rightarrow B \}$

Closure of a Set of Functional Dependencies

R (A, B, C, D)

FDs = {A -> B, B -> C, AB -> D}



Question GATE-2005

In a schema with attributes A, B, C, D and E following set of functional dependencies are given

{A -> B, A -> C, CD -> E, B -> D, E -> A}

Which of the following functional dependencies is NOT implied by the above set?

A. CD -> AC

B. BD -> CD

C. BC -> CD

D. AC -> BC

$A \rightarrow BC$

$CD \rightarrow E$

$B \rightarrow D$

$E \rightarrow A$

A) $CD^+ = \{C, D, E, A, \ldots$

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

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

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

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Question

R (A, B, C, X, Y, F, Z, G)

FDs = {A -> B, A -> Y, BC -> XY, AYZ -> G, Y -> C}

$A \rightarrow BY$

$BC \rightarrow XY$

$AYZ \rightarrow G$

$Y \rightarrow C$

$BY \rightarrow XY \Rightarrow BY \rightarrow X$

$BY \rightarrow Y$

$ABCZ \rightarrow G$

$AZ \rightarrow G$

$AC \rightarrow XY$

$AY \rightarrow XY$

$A \rightarrow C$

$A \rightarrow XY$

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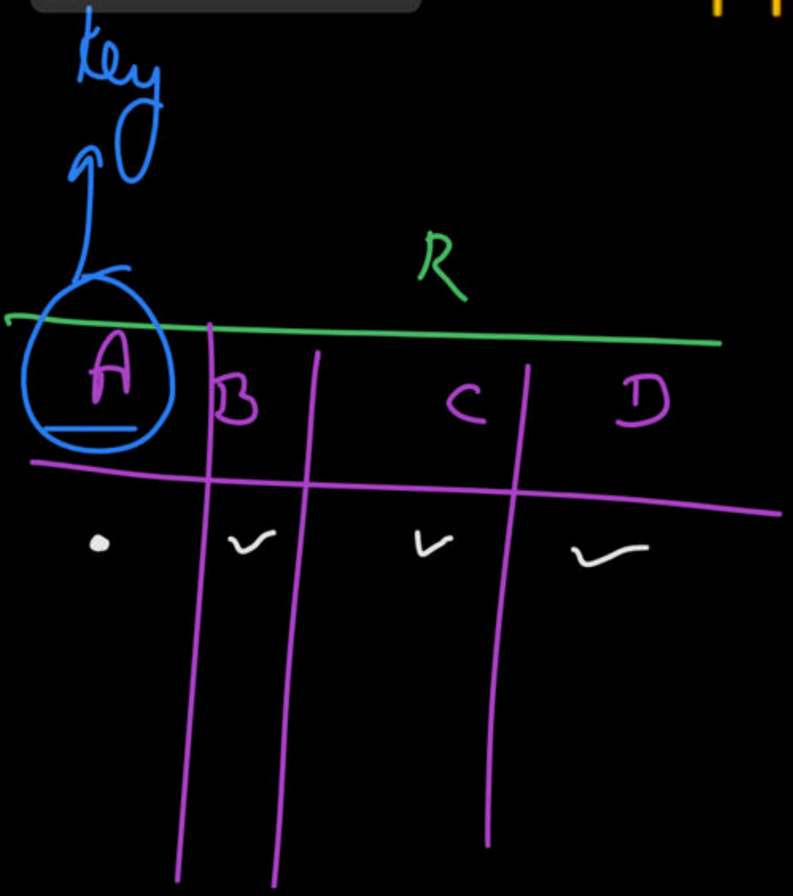
Finding Keys Using FDs

↳ candidate keys



if A is key

$A \rightarrow BCD$

directly or indirectly

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

all attributes

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Finding Keys Using FDs

Consider a relation R (A, B, C, D)

FDs = { A → B, B → C, C → D}

Find all keys?

$A \to B$

$B \to C$

$C \to D$

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

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

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

$D^+ = \{D\}$

C. key = {A}

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Question

Consider a relation R (A, B, C, D)

FDs = { A → B, B → C, C → D, D → A}

$A \to B$

$B \to C$

$C \to D$

$D \to A$

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

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

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

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

C.keys $= \{A, B, C, D\}$

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Question

Consider a relation R (A, B, C, D, E, F)

FDs = {

AB → C,

B → D,

C → E,

CD → F

}

$AB^{+} = \{A, B, C, D, E, F\}$

C.key = {AB}

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Question

Consider a relation R (A, B, C, D, E, F)

FDs = {

AB → D,

C → B,

D → CF,

B → E

}

$AB^+ = \{A, B, D, E, C, F\}$

$AC^+ = \{A, C, B, D, F, E\}$

$AD^+ = \{A, D, C, F, B, E\}$

c.keys = $\{AB, AC, AD\}$

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Question

Consider a relation R (A, B, C, D, E, F, G)

FDs = {

AB → D,

G → A,

D → F,

B → E,

E → C,

A → G,

C → B,

}

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Question

Consider a relation R (A, B, C, D, E, G)

FDs = {

AD → E,

AB → C,

B → D,

AC → B,

E → G,

BC → A

}

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Question

Consider a relation R (A, B, C, D, E, G)

FDs = {

$A \rightarrow B$,

$BC \rightarrow D$,

$E \rightarrow C$,

$D \rightarrow A$

}

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Question

Consider a relation R (A, B, C, D, F, G)

FDs = {

BCD → A,

BC → E,

A → F,

F → G,

C → D,

A → G

}

Find the minimal set?

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Happy Learning.!