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UNIT-3

Introduction to Schema refinement:

Schema refinement is intended to address and refinement approach based on decompositions. redundant storage of information is the root cause of this problems i.e, Associated with relational schema

problems caused by redundancy:

→ storing the same information redundantly i.e, in more than one place with in a database can lead to several problems

i) Redundant storage:- Some information is stored repeatedly.

ii) Update Anomalies:- If one copy of such repeated data is updated, and inconsistency is created unless all copies are similarly updated.

iii) Insertion Anomalies:- It may not be possible to store certain information unless some other, unrelated, information is stored as well.

iv) Deletion Anomalies:- It may not be possible to delete certain information without loosing some other, unrelated,

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information as well.

Name	rating	hourly-wages	hours-worked
Arsh	8	10	40
Smiley	8	10	30
Smith	5	7	30
Gudu	5	7	32
Madam	8	10	40

→ rating → hourly-wages [hourly-wages functionally dependent on rating]

→ Null values help in some cases of redundancy problems but it cannot provide a proper solution to the problem.

→ decomposition:- decomposition can eliminate Redundancy

→ functional dependencies [FD] can be used to identify such a situations and suggest refinements to the problem schema

→ A decomposition of a relational schema R consists of replacing the relational schema by two or more Relation schemas that each contain a subset of the attributes of R and together include all attributes in R.

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Ex:→ Table 1 (name, rating, hourly-worked)
Table 2 (rating, hourly-wages)

Table - 1

name	rating	hourly worked
Ansh	8	40
Smiley	8	30
smith	5	30
Gudie	5	32
madam	8	40

Table 2

rating	h-wages
8	10
5	₹

decomposition problems:

decomposing a relation schema can create more problems than it solves. Two important questions must be asked repeatedly.

Q1) Do we need to decompose a relation

A) Normalisation

Q2) What problems (if any) does a given decomposition cause?

A) i) Loss less Join decomposition property

ii) dependancy preservation property

* FUNCTIONAL DEPENDENCY:

A FD is a kind of integrity constraints that generalize the concept of key

Let R be a Relation Schema & let X, Y be non-empty sets of attributes in R. An instance 'r' of R satisfies the FD

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$X \rightarrow Y$ · If the following holds for every pair of tuples $t1$ & $t2$ in r.

$X \rightarrow Y$ iff $t1.X = t2.X$, then $t1.Y = t2.Y$

$X \rightarrow Y$ is read as X Functionally determines Y or simply called as X determines Y

A	B	C	D
a1	b1	c1	d1
a1	b2	c1	d2
a2	b2	c2	d2
a2	b2	c2	d3
a3	b3	c2	d4

If

a1 → c3, c4 — It is not FD

a2, a3 → c1 — It is FD

A → B (NO)
A → C (Yes)
A → D (NO)
B → C (NO)
B → D (NO)
C → D (NO)

Reasoning about functional dependencies:-

Workers (SSN, name, lot, did, since)

SSN → did holds [FD]
did → lot holds [FD]
then SSN → lot holds [FD]

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*Closure Set of FD's :-

The set of all FD's implied by a given set F of FD's is called the closure of F denoted as $[F^+]$

Inference Rules of FD's :- [Armstrong's Axioms]

→ X, Y and Z to denote set of attributes over a Relation schema R :

i) Reflexivity: If $X \supseteq Y$, then $X \to Y$

ii) Augmentation :→ If $X \to Y$, then $XZ \to YZ$ for any Z

iii) Transitivity :- If $X \to Y$ and $Y \to Z$ then $X \to Z$

Some additional rules added

iv) Union or Additive Rule :→ If $X \to Y$ and $X \to Z$, then $X \to YZ$

v) Decomposition :→ If $X \to YZ$ then $X \to Y$ and $X \to Z$

vi) Pseudo-Transitive Rule :- If $\alpha \to Y$ & $YZ \to W$ then $XZ \to W$

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F(C, S, J, D, P, Q, V)

Eg:- C → CSJDPQV

JP → C

SD → P

Ref :→ C → C; C → S, C → J, C → P, C → D,
C → Q, C → V

Aug :- If SD → P then SDJ → JP

Transitivity :→ If JP → C & C → CSJDPQV then
JP → CSJDPQV

* Attribute closure (x^+) :-

closure = X;

repeat until there is no change:

{ if there is an FD U → V in F such that U ⊆ closure, then set closure = closure ∪ V }

Ex :→ Compute the closure of the following set F of FD's for Relation schema R and R(A, B, C, D, E)

FD's are AB → C, CD → E, DE → B

list the candidate keys for R.

$A^+ = \{A\}$ $AB^+ = \{A, B, C\}$ $ABC^+ = \{A, B, C$

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

$C^+ = \{C\}$ $AD^+ = \{A, D\}$ $ABE^+ =$

$D^+ = \{D\}$ $AE^+ = \{A, E\}$

$E^+ = \{E\}$

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

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

$BE^+ = \{B, E\}$

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

$DE^+ = \{D, E, B\}$

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

ABD ACD

{ABD,

{A, E,}

CD, BC are candidate keys

Ex:-2 $R = \{A, B, C, D, E\}$

$A \to BC$, $CD \to E$, $B \to D$ $E \to A$

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

$[B^+] = \{B, D\}$

$[C^+] = \{C\}$

$[D^+] = \{D\}$

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

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

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

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Super key:- Specifies that no two distinct tuple can have same value for super key. set of attributes used to differ all tuples. It may have redundant values
→ superset of attributes to the candidate key is super key. but not every super key not a candidate key.

definition of super key:-
A super key is a set attributes with in a table whose values can be used to uniquely identify a tuple.

Ex:- BOOK

Bid	Bname	Author
B1	XYZ	A1
B2	ABC	A1
B3	XYZ	A2
B4	PQR	A3
B5	SRP	A1
B6	ABC	A3

{Bid}
SK={Bname, Author}
{Bid, Bname}
{Bid, Bname, Author}
↓
trival SK

the redundant values are accepted in SK

Candidate key:- A candidate key is a minimal set of attributes necessary to identify a tuple this is also called as

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minimal super key

Ex:→ CK = {Bid}

NOTE:- If more than one are candidate keys then if the database designer one candidate key from two, the one key which is selected by database designer is declared as primary key.

and the which are not selected as pk. is called Alternate key

→ CK & PK are same which is used to identify tuples uniquely with in the relation.

→ pk is the minimal super key.

→ Normally pk is composed of only a single attribute. but it is possible to have a pk composed of more than one attribute thin the more no of primary keys are called as composite attributes

Ex:- ① R(A, B, C, D, E)

$A \to C \quad C \to B \quad D \to E$

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

$B^+ = \{B\}$

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primary
attributes

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

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

$E^+ = \{E\}$

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

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

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

$\{AE^+\} = \{A, E, C, B\}$

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

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

$\{BE^+\} = \{B, E\}$

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

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

$\{DE^+\} = \{D, E\}$

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

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

$\{ABE^+\} = \{A, B, E, C\}$

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

$\{ACE^+\} = \{A, C, B, E\}$

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

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

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

$\{BDE^+\} = \{B, D, E\}$

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

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

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

SK = { AD, ACD, ADE, ABCD, ACDE, ABCDE, ADBE }

CK = { AD }

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2nd I

② $R(A, B, C, D, E, F)$

$A \to C$, $C \to D$, $D \to B$, $E \to F$

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

$B^+ = \{B\}$ $CK = \{AE\}$

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

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

$E^+ = \{E, F\}$

$F^+ = \{F\}$

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

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

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

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

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

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

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

$BE^+ = \{B, E, F\}$

$BF^+ = \{B, F\}$

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

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

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

$DE^+ = \{D, B, E, F\}$

$DF^+ = \{D, B, F\}$

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(b) $R(A, B, C, D, E)$

$A \rightarrow BCDE$, $BC \rightarrow ADE$

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

$B^+ = \{B\}$

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

CK: $\{A^{\oplus}\}$, $\{BC^{\oplus}\}$

PK: $\{A\}$

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Normal Forms:

Breaking table or relation into more relations. The relation is going to be decompose with the help of Normal forms

→ Normalization is a database design technique which organises table in a manner that reduces redundancy and dependency of data

→ It divides larger tables to smaller tables and links them using relationships

→ It is a systematic approach of decomposing tables to eliminate data redundancy and undesirable characteristics like insertion, deletion and update Anamalies

→ It is a multi step process that puts data into tabular form removing duplicated data from relation tables.

→ Normalization is used for mainly two purpose:

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i) eliminating redundant data (for example, ...
ii) ensuring data dependencies make sense ...
data is logically stored.

- Normalization rules are divided into ...
following normal forms (there are only ...
rules and set of rules to perform during ...
options)

1. First Normal form [1NF]
2. Second Normal form [2NF]
3. Third Normal form [3NF]
4. Boyce codd Normal form [BCNF]
5. Fourth Normal form [4NF]
6. Fifth Normal form [5NF].

1NF:-

It should follow the following rules

i) It should only have single valued attribute (Atomic)

ii) Each record needs to be unique

iii) All the columns in a table should have unique names

iv) No composite values

v) Values stored in column should be of the same domain

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Ex:→

Student

Roll NO	Name	courses
101	A	DBMS, SC, FLAT
102	B	FLAT, DS
103	C	DS, DBMS, SE

Student table is not in 1NF. TO make Student table in 1NF.

Student

Roll NO	Name	courses
101	A	DBMS
101	A	SE
101	A	FLAT
102	B	FLAT
102	B	DS
103	C	DS
103	C	DBMS
103	C	SE

2NF:

i) For a relation to be in the second NF It should be in the 1NF

ii) And it should not have partial dependency (or) it should contains only fully functional dependency.

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Ex:- F(A, B, C, D, E, F)

$A \rightarrow BCDEF$

$BC \rightarrow ADEF$

$B \rightarrow F$

$D \rightarrow E$

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

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

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

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

CK : A, BC [prime attributes]

(NPA) Nonprime attributes :- D, E, F

NPA :- D is fully functional dependent on A, BC

E is fully FD on A, BC

F is not fully FD on BC.

there was problem with F so it is placed in another table.

To make it in 2NF

F(A, B, C, D, E, F)

F1(A, C, D, E, B)

$A \rightarrow BCDE$

$BC \rightarrow ADE$

$D \rightarrow E$

F2 (B, F)

$B \rightarrow F$

common attribute

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Q:- R (A, B, C, D, E)

$AB \rightarrow C$

$C \rightarrow D$

$B \rightarrow E$

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

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

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

$xy \rightarrow w$

$y \rightarrow w$

(partial).

(PA) CK : {AB}

NPA : {C, D, E}

C is fully FD on AB.

D is not Fully FD on AB

E is not Fully FD on AB

R(A, B, C, D, E)

R1 (A, B, C, D)

$AB \rightarrow C$

$C \rightarrow D$

CK:- AB

NPA:- C, D

2NF

R2 (B, E)

$B \rightarrow E$

CK:- B

NPA:- E

2NF

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3NF:

i) Relation should be in 2NF

ii) Relation should not contain any Transitive dependency. (or)

$X \to Y$ be the Non-trivial FD is in 3NF if X should be candidate key or super key or Y should be prime Attribute

[Note:- there should not be the case that a NPA is determined by another NPA]

$R1(A,B,C,D)$

$AB \to C$

$C \to D$

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

$Ck = \{AB\}$ (PA)

NPA = C, D

$R2(B,E)$

$B \to E$

Ck :- B (PA)

NPA :- E

II NF

$R1(A,B,C,D)$

$R1(A,B,C)$

$AB \to C$

3NF

Also in BCNF

$R3(C,D)$

$C \to D$

NF

BCNF

$R2(B,E)$

$B \to E$

3NF

BCNF

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F(A,B,C,D,E,F)

F1(A,B,C,D,E)

A → BCDE
BC → ADE
D → E

$A^+ = \{A,B,C,D,E\}$
$BC^+ = \{B,C,A,D,E\}$
$D^+ = \{D,E\}$
PA :- {A, BC}

F2(B,F)

B → F

3NF
BCNF

F1(A,B,C,D,E)

F1.1(A,B,C,D)

A → BCD
BC → AD
PA :→ A, BC

3NF
BCNF

F1.2(D,E)

D → E
PA :- D

3NF
BCNF

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BCNF:

i) It has to be in 3NF

ii) In relation $X \to Y$ is a non-trivial FD of X should contain candidate key or super key

Ex:- R(A, B, C, D)

$A \to BCD$

$BC \to AD$

$D \to B$

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

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

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

CK:- $\{A, BC\}$

NPA :- D

It is in 3NF

R(A, B, C, D)

If we take B as common then it will not be in 3NF satisfying transitive property

R1(A, C, B)

$A \to BCD$

$C \to AD$

CK:- $\{A, C\}$ NPA-D

BCNF

R2(B, D)

$D \to B$

PA:-D

NPA:-B

BCNF

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determine NF for given relations.

1) R(V, W, X, Y, Z)

VY → W

WX → Z

ZY → V

3NF

2) R(A, B, C, D, E)

A → BC

BCD → AE

2NF

3) R(A, B, C, D, E, F, G)

A → B

BC → DE

AEF → G

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

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

$AEF^+ = \{A, E, F, B, G\}$

1NF

4) R(N, O, P, Q, R)

N → OPQ

OPQ → R

R → PQ

$N^+ = \{O, P, Q, N, R\} \Rightarrow$ PA

$OPQ^+ = \{O, P, Q, R\}$

$R^+ = \{P, Q, R\}$

2NF

5) R(A, B, C, D, E)

AB → C

B → D

C → E

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

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

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

(1NF)

6) R(A, B, C, D)

AB → CD

B → A

C → D

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

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

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

3NF

BCNF

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2:1

1) R(V, W, X, Y, Z)

VY → W

WX → Z

ZY → V

$VY^+ = \{V, Y, W\}$

$WX^+ = \{W, X, Z\}$

$ZY^+ = \{Z, Y, V, W\}$

(2NF) $VYW^+ = (V, Y, W)$

VYWXZ

2) R(A, B, C, D, E)

A → BC

D → AE

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

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

PA :- D

2NF

4NF:

For a table to satisfy the fourth Normal form it should satisfy the following conditions

1) It should be in the BCNF
2) The table should not have any multi-valued dependency (or)

In Relation R for every multi valued dependency (X →→ Y) that hold over relation R has to be a) $Y \subseteq X$ or $XY = R$ (or)

b) X is a Super Key

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Multi-valued dependency:

A table is said to have multi-valued dependency if the following conditions are true.

1) For a dependency A → B if for a single value of A multiple value of B exists then the table may have multi-valued dependency.

2) Also a table should have atleast 3 columns for it to have a multi-valued dependency. (OR)

A multi-valued dependency consists of atleast 2 attributes that are dependent on third attribute thats why it always requires atleast 3 attributes.

3) And for a relation R(A,B,C) if there is a multivalued dependency between A & B then B & C should be independent of each other. (OR)

Multi-valued dependency occurs when two attributes in a table are independent of each other but both depend on a third attribute.

→ If all these conditions are true for any relation OR table then it is said to have multi valued dependency.

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Eg:→ student

Sid	course	hobby
1	science	cricket
1	maths	Hockey
2	C#	cricket
3	php	Hockey

⇒ course

Sid	course
1	science
1	maths
2	C#
2	php

a1 — b1
a1 — b2

Hobbies

Sid	Hobby
1	cricket
1	hockey
2	cricket
2	Hockey

So there is a multivalued dependency which leads to unnecessary repetation of data and other Anamolies as well.

→ To make the student in 4th NF decompose the student table into two tables they are course table & Hobbies table

→ Now course tables & Hobbies tables are in 4NF.

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course

std	course
1	science
	maths
	C#
	php

→ A table can also have Functional dependency along with multivalued dependency. In that case the functional dependency columns are moved in a separate table and the multi valued dependent columns are moved to separate table.

Eg:→ Student 1

sid address course hobby

sid → address (FD)
sid →→ course
sid →→ hobby

decomposed into 3 tables:

(sid → address) (sid →→ course) (sid →→ hobby)

I table — Address table
II table — course table
III table — hobby table

NOTE:- for fourth NF a relation has to be in BCNF and a given relation contain more than one multi valued attributes.

Eg:→

sid	subject	Activity
1	music	Tennis
1	Accounting	Tennis
1	music	swimming
1	Accounting	swimming

sid →→ subject
sid →→ Activity

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Table 1

sid	subject
1	music
1	Accounting

Table 2

sid	Activity
1	Tennis
1	swimming

Table:

P	M	F
P1	M1	F1
P1	M2	F2
P1	M1	F2
P1	M2	F1
P2	M3	F2

$P \twoheadrightarrow M$

$P \twoheadrightarrow F$

multivalued dependency

1) MVD occurs when 2 attributes in a table are independent of each other but, both depend on a third attribute.

2) A MVD consists of atleast 2 attributes that are dependent on a 3rd attribute that's why it always requires atleast 3 attributes

If $R(X,Y,Z)$ i.e. If $X \twoheadrightarrow Y$ holds over Relation R

and $Z = R - XY$

* MVDS :- If $X \twoheadrightarrow Y$ holds over R, then

$$\Pi_{YZ}(\sigma_{X=x}(R)) = \Pi_{Y}(\sigma_{X=x}(R)) \times \Pi_{Z}(\sigma_{X=x}(R))$$

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Inference rules consists of the 3 Armstrong Axioms

There are of the additional rules involve only MVD's

1) MVD complementation:- If $X \twoheadrightarrow Y$, then $X \twoheadrightarrow R - XY$

2) MVD Augmentation:- If $X \twoheadrightarrow Y$ and $W \supseteq Z$, then $WX \twoheadrightarrow Y$

3) MVD transitivity:- If $X \twoheadrightarrow Y$ and $Y \twoheadrightarrow Z$ then $X \twoheadrightarrow (Z-Y)$

Additional Rules :

The remaining 2 rules relate FD's and MVD's

4) Replication: If $X \to Y$, then $X \twoheadrightarrow Y$

5) Coalescence: If $X \twoheadrightarrow Y$ and there is a W such that $W \cap Y$ is empty, $W \to Z$, and $Y \supseteq Z$, then $X \to Z$

Note :- Every FD is also an MVD

4NF definition :→ 1) R has to be in BCNF

Note :- 1) Trival FD:- A set of attributes which are called a trivial if the set of attributes are included in that attribute.

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2:1

so $X \to Y$ is a TFD if Y is a subset of X

2) Non trivial FD:- when $A \to B$ holds true where B is not a subset of A.

22/2/20 5NF:-

A relation is in 5th normal form if it is in 4NF and not contains any Join dependency

→ 5NF is satisfied when all the tables are broken into as many tables as possible in order to avoid redundancy.

→ 5NF is also known as project-Join NF [PJ/NF]

ex:-

Suppliers	parts	project
S1	P1	r1
S1	P2	r2
S2	P1	r1
S2	P1	r2

NOTE: If Join dependency not exists then the relation R is in 5NF else if Join dependency exists then it is trivial Join dependency then that relation is in Join dependency, else if all R_i where $R_1 \to R_1, R_2, \ldots R_n$

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i.e $i = 1, 2, \ldots n$ is Super key then it is said to be in 5NF

R1

Supplies	parts
S1	P1
S1	P2
S2	P1

R2

Supplies	project
S1	r1
S1	r2
S2	r1
S2	r2

R3

parts	project
P1	r1
P2	r2
P1	r2

R1 ⋈ R2

Suppliers	parts	project
S1	P1	r1
S1	P1	r2
S1	P2	r1
S1	P2	r2
S2	P1	r1
S2	P1	r2

R1 ⋈ R2 ⋈ R3

Suppliers	parts	project
S1	P1	r1
S1	P1	r2
S1	P2	r2
S1		

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2:1

properties of decomposition

→ Relational Decomposition:-
When the relation in a relational model is not in appropriate NF then the decomposition of relation is required.
→ In a database it breaks the table into multiple tables.
→ If the relation has no proper decomposition then it may lead to problems like loss of information.
* decomposition is used to eliminate some of the problems of bad design like Anomalies, Inconsistencies and redundancy

→ Types of decompositions:
There are two types
1) Loss less decomposition
2) dependency preserving

Loss less decomposition: If the information is not lost from the relation i.e decomposed then the decomposition will be lossless
→ The loss less decomposition guarantees that the Join of relations will result in the same relation as it was decomposed.

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* the relation is said to be loss less decomposition if Natural Joins of all the decomposition give the Original relation.

Ex:- employee- department table.

Emp-ID	Emp-Name	Emp-age	Emp-city	Dept-ID	Dept-Name
22	Denim	28	mumbai	827	Sales
33	Alina	25	Delhi	438	marketing
46	Stephan	30	Banglore	869	Finance
52	katherine	36	Mumbai	575	production
60	Jack	40	Noida	678	Testing

Employeetable

Emp-ID	Emp-name	Emp-age	Emp-city
22	Denim	28	mumbai
33	Alina	25	Delhi
46	Stephan	30	Banglore
52	katherine	36	Mumbai
60	Jack	40	Noida

Department table

emp-Id	Dept-ID	Dept-Name
22	827	Sales
33	438	Marketing
46	869	Finance
52	575	production
60	678	Testing

Employee ⋈ Department

Emp-Id	Emp-name	Emp-age	Emp-city	Dept-ID	Dept-Name
22	Denim	28	mumbai	827	Sales
33	Alina	25	Delhi	438	marketing
46	Stephan	30	banglore	869	Finance
52	katherine	36	mumbai	575	production
60	Jack	40	Noida	678	Testing

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Hence the decomposition is loss-less join decomposition.

→ dependency preserving:
It is an important constraint of the database. On the dependency preservation atleast one decomposed table must satisfy every dependency

→ If a relation R is decomposed into Relation R1 and R2 then the dependency of R either must be a part of R1 or R2 or must be derivable from the combination of functional dependencies of R1 & R2

→ for example:- Suppose there is a relation R (A, B, C, D) with functional dependency set A → BC the relation R is decomposed into R1(A, B, C) & R2(A, D) which is dependency preserving. bcoz functional dependency A → BC is a part of relation R1(A, B, C)

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