Fourth Normal Form (4NF)

A relation R is in 4NF if and only if the following conditions are satisfied:

- R is already in 3NF or BCNF
- If it is contained no MVDs

Fourth Normal Form (4NF)

Multi Valued Dependency(MVD)

- It is the dependency where one attribute value is potentially a **multi valued fact** about other
- Important:
  - There must be 3 or more attributes
  - Attributes must be independent of each other

F.D(α→β) says that we can't have two tuples with same α value but different β value

- MVD(**α→→β**) **: if any legal relation r(R) for all pairs of tuples t1 and t2 in r such that t1(α)=t2(α) then there exist tuple t3 and t4 in r such that**
  - **t3(α)=t4(α)= t1(α)=t2(α)**
  - **t3(β)=t1(β)**
  - **t4(β)=t2(β)**

Fourth Normal Form (4NF)

Multi Valued Dependency(MVD)

Person(P)	Mobile(M)	FOOD_LIKE(F)
P1	M1 M2	F1 F2
P2	M3	F2

t3(α)=t4(α)= t1(α)=t2(α)
t3(β)=t1(β)
t4(β)=t2(β)

	α	**β**		
	Person(P)	**Mobile(M)**	**FOOD_LIKE(F)**	
t1	**P1**	**M1**	**F1**	**(P→→M)**
t2	**P1**	**M2**	**F2**	**(P→→F)**
t3	**P1**	**M1**	**F2**	
t4	**P1**	**M2**	**F1**	
	P2	**M3**	**F2**	

Fourth Normal Form (4NF)

Multi Valued Dependency(MVD)

- MVD occurs if two or more independent relations are kept in a single relation.

- Consider 2 relations: R1(Sid, Sname) R2(Cid, Cname)

Sid	Sname
S1	A
S2	B

Cid	Cname
C1	C
C2	B

- Merging using cross product

Sid	Sname	Cid	Cname	
S1	A	C1	C	**(Sid→→Cid)**
S1	A	C2	B	**(Sid→→Cname)**
S2	B	C1	C	
S2	B	C2	B	

Fourth Normal Form (4NF)

- Consider the following table Student(name, computer, language) with the following records. Normalize the table. Is the table is in 4NF? If no decompose to 4NF

Name	Computer	Language
Aman	Windows/ Apple	English Hindi
Mohan	Linux	English Spanish

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Name	Computer	Language
Aman	Windows	English
Aman	Windows	Hindi
Aman	Apple	English
Aman	Apple	Hindi
Mohan	Linux	English
Mohan	Linux	Spanish

R1

Name	Computer
Aman	Windows
Aman	Apple
Mohan	Linux

R2

Name	Language
Aman	English
Aman	Hindi
Mohan	English
Mohan	Spanish

Key: (name,compr) key(name,language)

name->>computer name->>language

Fourth Normal Form (4NF)

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Name	Computer	Language
Aman	Windows/ Apple	English Hindi
Mohan	Linux	English Spanish

-

Name	Computer	Language
Aman	Windows	English
Aman	Windows	Hindi
Aman	Apple	English
Aman	Apple	Hindi
Mohan	Linux	English
Mohan	Linux	Spanish

R2

name	Language
Aman	English
Aman	Hindi
Mohan	English
Mohan	Spanish

Key: (name,computer)

name→→computer

Fourth Normal Form (4NF)

- Consider the following table . The table has multivalued dependencies as:

a)Department→job

b) Department→part

c) Both a and b

d) none

Department	Job	Part
d1	j1	p1
d1	j1	p2
d1	j2	p1
d1	j2	p2
d2	j3	p2
d2	j3	p4
d2	j4	p2
d2	j4	p4
d2	j5	p2
d2	j5	p4
d3	j2	p5
d3	j2	p6

Solution:

t1 : d1 j1 p2

t3: d1 j1 p2

t4: d1 j2 p1

t2: d1 j2 p2

X→→Y : t1(x)=t2(x) then

t1(x)=t2(x)=t3(x)=t4(x)

t1(y)=t3(y) and t2(y)=t4(y)

t1(z)= t4(Z) and t2(z)=t3(z)

Department→→ Job

Fifth Normal Form (5NF)

- Consider a relation R

Supplier	Parts	Project
S1	P1	R1
S1	P2	R2
S2	P1	R1
S2	P1	R2

R1

Supplier	Parts
S1	P1
S1	P2
S2	P1

R2

Supplier	Project
S1	R1
S1	R2
S2	R1
S2	R2

R3

Parts	Project
P1	R1
P1	R2
P2	R2

Fifth Normal Form (5NF)

- R must be in 4NF

If join dependency not exist

→5NF

else join dependency exist

if only trivial JD (R->R1,R2,R3 and any Ri is R)=> R-> R R2 R3

→5NF

else (all Ri is superkey)

→5NF

else

not in 5NF

5NF

Fifth Normal Form(5NF): **A relation R is in 5th normal form if and only if the following conditions are satisfied simultaneously**

i. **R is already in 4NF(No M.V.D in R)**
ii. **It cant be further non-loss decomposed**

Join Dependency : Let 'R' be a relation schema and R1,R2,....Rn be the decomposition of R, R is said to satisfy the join dependency (R1,R2,...Rn) if and only if

$\pi R1(R) \bowtie \pi R2(R) \bowtie \ldots\ldots\ldots \bowtie \pi Rn(R)$ **= R (Order of Join Doesn't matter)**

OR

If and only if every legal instance r(R) equal to join of its projections on R1,R2,..,Rn

Example of Join Dependency

Agent	Company	Product
Aman	C1	Pendrive
Aman	C1	MIC
Aman	C2	Speaker
Mohan	C1	Speaker

5NF

Join Dependency Rule: Holds good only if a table can be retransformed back without any loss of information from the join of certain specified projections on it
[find JDs in table and if it exists the table is not in 5NF]

R1

Agent	Company
Aman	C1
Aman	C2
Mohan	C1

R2

Agent	Product
Aman	Pendrive
Aman	MIC
Aman	Speaker
Mohan	Speaker

R3

Company	Product
C1	PD
C1	MIC
C1	Speaker
C2	Speaker

R1 ⋈ R2

Agent	Company	Product
Aman	C1	PD
Aman	C1	MIC
Aman	C1	Speaker
Aman	C2	PD
Aman	C2	MIC
Aman	C2	Speaker
Mohan	C1	Speaker

≠ **R**

Agent	Company	Product
Aman	C1	Pendrive
Aman	C1	MIC
Aman	C2	Speaker
Mohan	C1	Speaker

5NF

A relation R is in 5NF w.r.t a set of F of functional, multivalued and join dependencies if for every non trivial join dependency (R1,...Rn) in F+, every R1 is a superkey of R

Q. Is the table in 5NF

Pname	Skill	Job
Aman	DBA	J1
Mohan	DBA	J2
Rohan	Programmer	J3
Sohan	Analyst	J1

5NF

R1(Pname,Skill)

Pname	Skill
Aman	DBA
Mohan	Tester
Rohan	Programmer
Sohan	Analyst

R2(Pname,Job)

Pname	Job
Aman	J1
Mohan	J2
Rohan	J3
Sohan	J1

$(R1 \bowtie R2 \bowtie R3)=R$

Pname	Skill	Job
Aman	DBA	J1
Mohan	Tester	J2
Rohan	Prog	J3
Sohan	Analyst	J1

Skill	Job
DBA	J1
Tester	J2
Programmer	J3
Analyst	J1

‘R’ is not in 5NF

not equal to Key of ‘R’