

# [Lossless Decomposition]



A	B	C
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Decompose

A	B
---	---

A	C
---	---

Join


If this  
contains  
extra rows/tuples

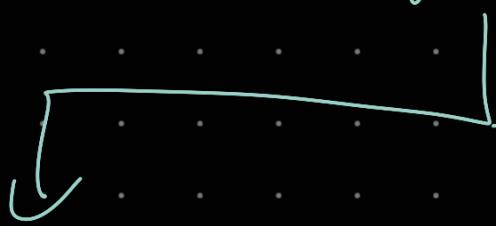
then the decomposition  
was Lossy decomposition

- \* Actually we are not losing data but extra data is added
- \* When we Decompose a large table to small tables, it should be lossless  $\rightarrow$  No extra data should be added

## [FD preservation]

$R(A_1, A_2, \dots, A_n)$

$F^+ = \{ \text{set of all FD in } R \}$



$R_1$

$F_1 \subseteq F^+$

$R_2$

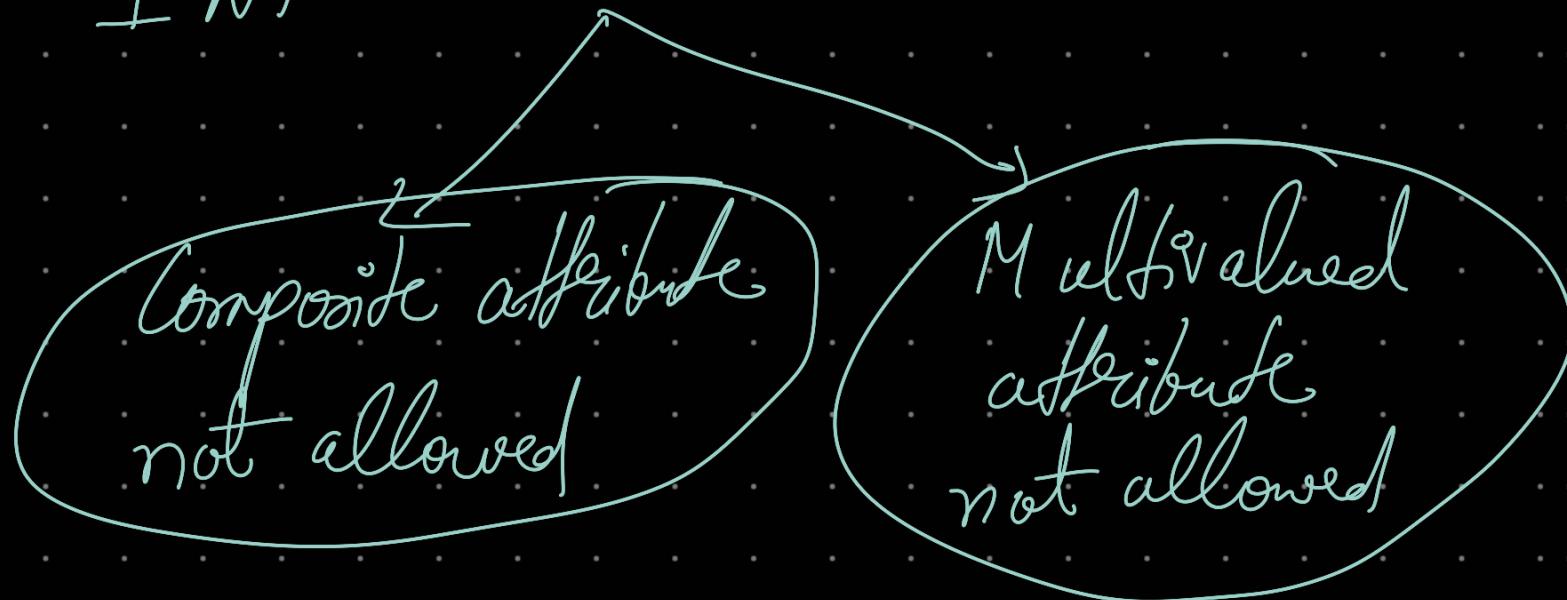
$F_2 \subseteq F^+$

\*  $I\beta(F_1 \cup F_2)^+ = F^+$   
↓  
~~FD preserved~~

- \* FD preserving is not compulsory
- \* Lossless join is compulsory

[ 1 NF ]

\* By default every table is in  
1 NF



A table is in 1NF if:

- All columns contain only atomic (indivisible) values.
- Each column contains only one type of data.
- Each row is unique.

Example:

Non-1NF Table:

EmployeeID	EmployeeName	Skills
1	John Doe	Java, Python
2	Jane Roe	SQL, JavaScript

Mul value attribute

1NF Table:

EmployeeID	EmployeeName	Skill
1	John Doe	Java
1	John Doe	Python
2	Jane Roe	SQL
2	Jane Roe	JavaScript

[2 NF]

- ① Should be in 1NF
- ② All non-key attribute should be fully functional dependent on primary key.

A	B	C
1	a	c <sub>1</sub>
2	a	c <sub>1</sub>
1	b	c <sub>2</sub>
2	b	c <sub>2</sub>

$\Rightarrow A B \rightarrow C$

$B \rightarrow C$

$$A^+ = \langle A \rangle$$

$$B^+ = \langle B, C \rangle$$

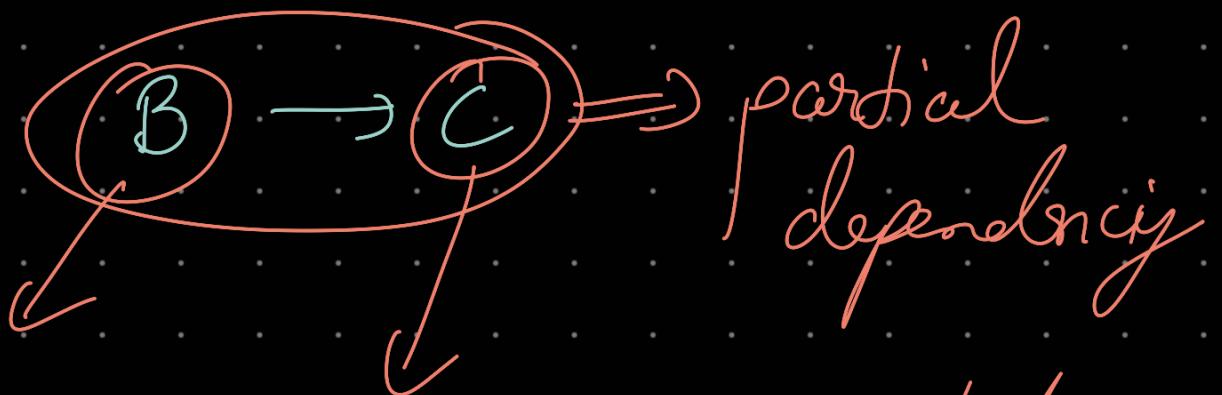
$$C^+ = \langle C \rangle$$

$$(AB)^+ = \langle A, B, C \rangle \Rightarrow \text{Candidate Key}$$

$$(BC)^+ = \langle B, C \rangle$$

$$(AC)^+ = \langle A, C \rangle$$

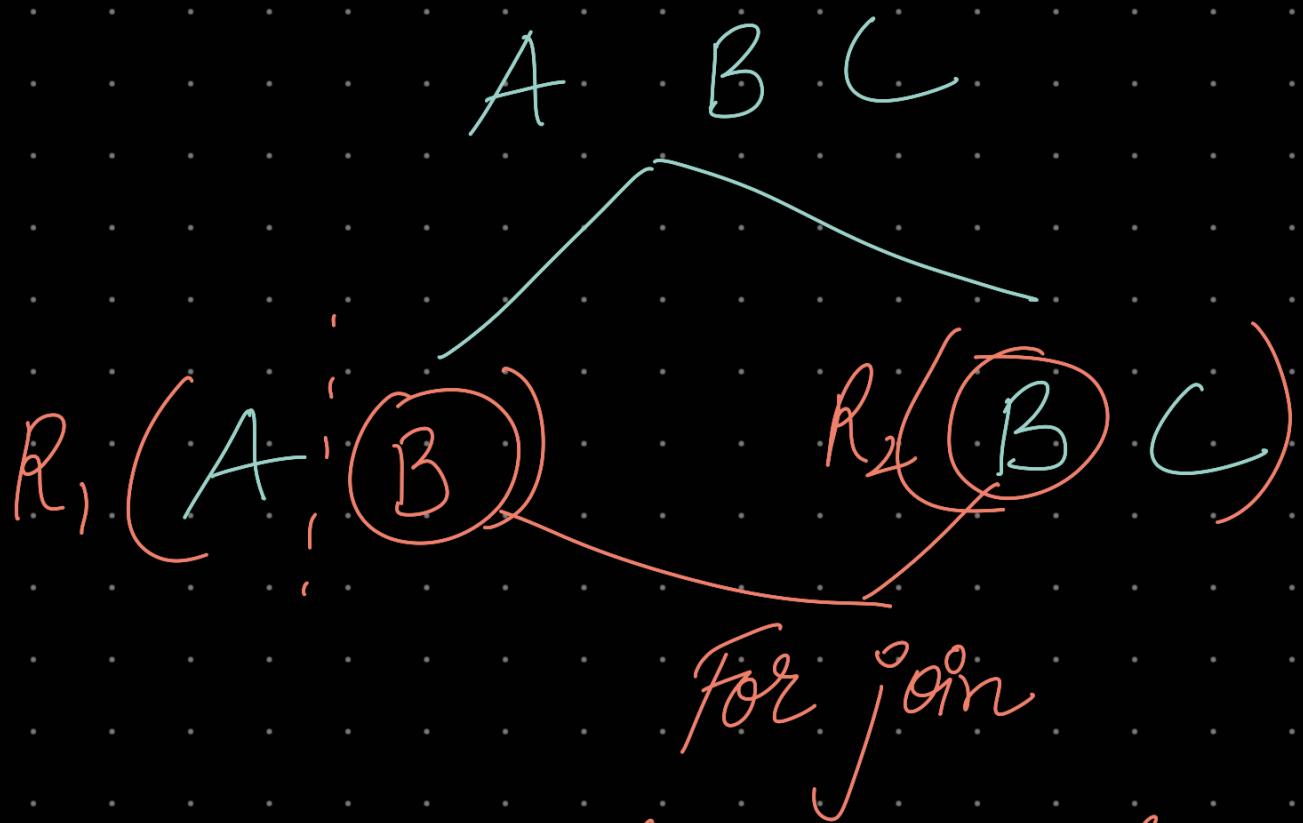




Key attribute      non-Key attribute

\* Not In 2NF

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



\* This should be lossless

\* May or May not be FP preserving

Example:

Non-2NF Table (with partial dependency):

OrderID	ProductID	ProductName	Quantity
1	101	Widget	10
1	102	Gadget	5
2	101	Widget	2

2NF Tables:

Orders Table:

OrderID	ProductID	Quantity
1	101	10
1	102	5
2	101	2

Products Table:

ProductID	ProductName
101	Widget
102	Gadget

\* If we see above, Some redundant data was removed in 2NF

\*  $X \rightarrow Y$  Imp

- ① Both Non-prime or Both prime  $\rightarrow$  Not partial
- ② X prime, Y non-prime  $\rightarrow$  Partial dependency

## [3NF]

- ① Should be in 2NF
- ② All attributes are functionally dependent on primary key.
- \* No transitive dependency.

E.g.  $R(A, B, C)$

A	B	C
1	a	c <sub>1</sub>
2	a	c <sub>1</sub>
3	b	c <sub>2</sub>
4	b	c <sub>2</sub>
5	b	c <sub>2</sub>

$A \rightarrow B$

$B \rightarrow C$

repetition.

$\hookrightarrow$  It's in 2NF

No partial dependency

$$A^+ = [A, B, C]$$

$\hookrightarrow$  Candidate Key

$A \rightarrow$  prime attribute / column

$B, C \Rightarrow$  Non-prime " "

$(B \rightarrow C) \rightarrow$  Transitive Dependency

$A B C$

$(A; B)$        $(B; C)$

$\underline{A}$	$\underline{B}$
1	a
2	a
3	b
4	b
5	b

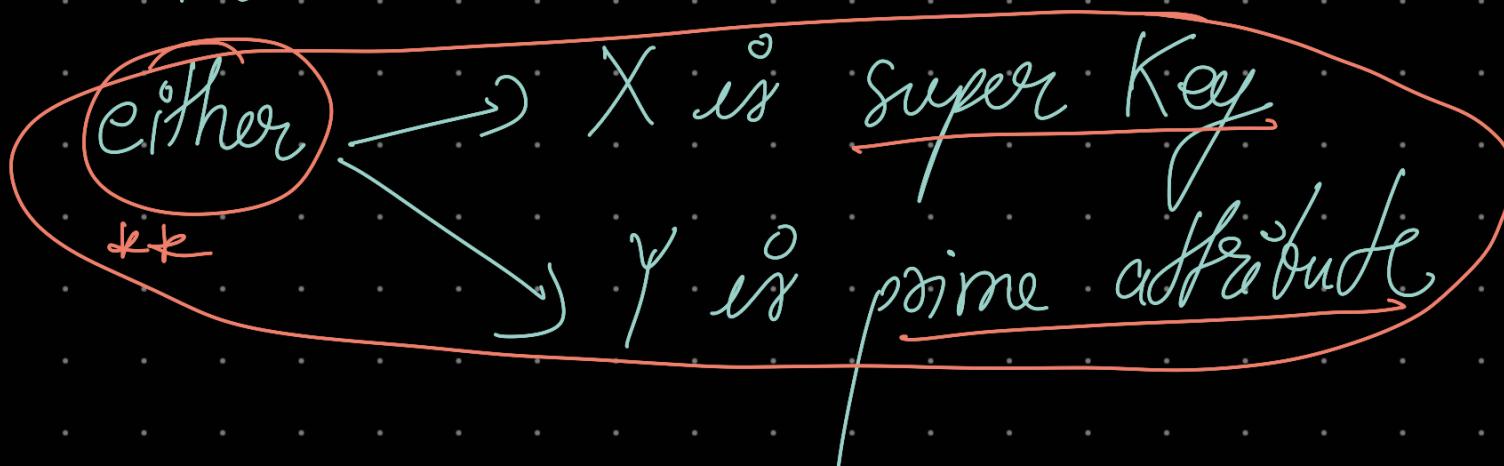
$\underline{B}$	$C$
a	c <sub>1</sub>
b	c <sub>2</sub>

Both in 3NF

\* Some redundant data was removed.

\* Another way of understanding 3NF

$$FD \rightarrow X \rightarrow Y$$



## 3NF Example

Original Table:

StudentID	StudentName	MajorID	MajorName
1	Alice	M01	Math
2	Bob	M02	Physics

Functional Dependencies:

1. `StudentID → StudentName, MajorID`
2. `MajorID → MajorName`
3. `StudentID → MajorName` (transitive dependency)

## Third Normal Form (3NF)

Students Table:

<u>StudentID</u>	StudentName	MajorID
1	Alice	M01
2	Bob	M02

Functional Dependencies:

1.  $\text{`StudentID} \rightarrow \text{StudentName, MajorID'}$

Majors Table:

<u>MajorID</u>	MajorName
M01	Math
M02	Physics

Functional Dependencies:

1.  $\text{`MajorID} \rightarrow \text{MajorName'}$

\* 3NF has removed redundant data.

[BCNF]

↓  
Boyce-Codd Normal form

- (1) should be in 3NF
- (2) ~~X~~ → Y

↳ X is super key for every FD

## BCNF Example

Original Table:

CourseID	Instructor	Textbook
CS101	Prof. A	Intro to CS
CS101	Prof. B	Intro to CS
CS102	Prof. B	Advanced CS

Functional Dependencies:

1. `CourseID, Instructor → Textbook`

Redundancy

↓ Decomposition

## Boyce-Codd Normal Form (BCNF)

Courses Table:

CourseID	Instructor
CS101	Prof. A
CS101	Prof. B
CS102	Prof. B

Functional Dependencies:

1.  $\text{CourseID}, \text{Instructor} \rightarrow (\text{None})$  (This table doesn't have non-trivial FDs involving super keys only, so it is in BCNF.)

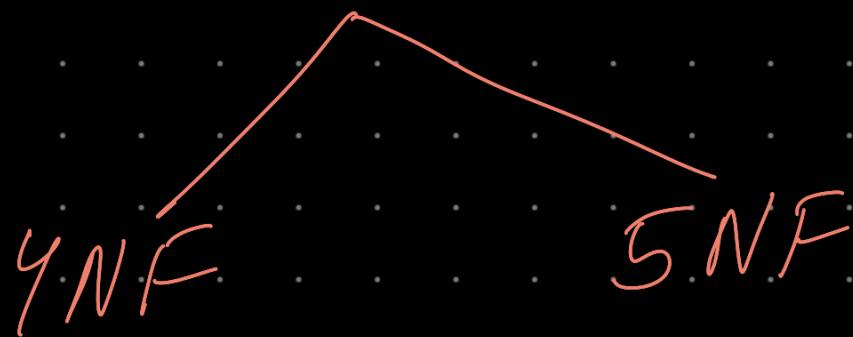
Textbooks Table:

CourseID	Textbook
CS101	Intro to CS
CS102	Advanced CS

Functional Dependencies:

1.  $\text{CourseID} \rightarrow \text{Textbook}$

There are two more NF



\* Enterprise takes attention upto  
(BCNF) for efficient data retrieval