

# Database Management System 17

## Normal Forms

Normal Forms

1NF(First Normal  
Form)

Partial FD

2NF(Second Normal  
Form)

Transitive FD

3NF(Third Normal  
Form)

BCNF (Boyce-Codd  
Normal Form)

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## Normal Forms

- Normal forms provide a stepwise progression towards the construction of normalized relation schemas, which are free from data redundancies
- A relation schema is said to be in a particular normal form if it is satisfying certain defined conditions

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## 1NF(First Normal Form)

### 1NF(First Normal Form)

A relation is in 1NF iff the values in the relation are **atomic** and **single-valued** for every attribute in the relation

Course

Module	Dept	Lecturer	Text
$M_1$	$D_1$	$L_1$	$T_1, T_2$
$M_2$	$D_1$	$L_1$	$T_1, T_3$
$M_3$	$D_1$	$L_2$	$T_4$
$M_4$	$D_2$	$L_3$	$T_1, T_5$
$M_5$	$D_2$	$L_4$	$T_6$

- As the Text column values are not atomic, this relation is not present in 1NF
- To convert this non-1NF relation into a 1NF relation, split up the non-atomic values

## 1NF(First Normal Form)...

Course1

Module	Dept	Lecturer	Text
$M_1$	$D_1$	$L_1$	$T_1$
$M_1$	$D_1$	$L_1$	$T_2$
$M_2$	$D_1$	$L_1$	$T_1$
$M_2$	$D_1$	$L_1$	$T_3$
$M_3$	$D_1$	$L_2$	$T_4$
$M_4$	$D_2$	$L_3$	$T_1$
$M_4$	$D_2$	$L_3$	$T_5$
$M_5$	$D_2$	$L_4$	$T_6$

Course2

Module	Dept	Lecturer	$Text_1$	$Text_2$
$M_1$	$D_1$	$L_1$	$T_1$	$T_2$
$M_2$	$D_1$	$L_1$	$T_1$	$T_3$
$M_3$	$D_1$	$L_2$	$T_4$	
$M_4$	$D_2$	$L_3$	$T_1$	$T_5$
$M_5$	$D_2$	$L_4$	$T_6$	

**Corollary: As the relation schema contains no data values, therefore all relation schemas are in 1NF**

Anomalies in 1NF Relations:

- Insertion anomalies
- Updation anomalies
- Deletion anomalies

### Partial FD

A FD  $A \rightarrow B$  is a partial FD, if some attribute of  $A$  can be removed and the FD still holds. That means there is some proper subset of  $A$ ,  $C \subset A$ , such that  $C \rightarrow B$

- **Key attributes:** are the attributes which are part of some candidate key
- **Non-key attributes:** are the attributes which are not part of any candidate key

## 2NF(Second Normal Form)

### 2NF(Second Normal Form)

A relation is in 2NF iff the following two conditions are met simultaneously:

- It is in 1NF
- No non-key attribute is partially dependent on any key

A non-2NF relation can be decomposed into 2NF relations by following:

- Create a new relation by using the attributes from the offending FD as the attributes in the new relation. The determinant of the FD becomes the primary key of the new relation
- The attribute on the RHS of the FD is then eliminated from the original relation
- If more than one FD prevents the relation from being 2NF, repeat steps 1 and 2 for each offending FD
- If the same determinant appears in more than one FD, place all the attributes functionally dependent on this determinant as non-key attributes in the relation having the determinant as the primary key

## 2NF(Second Normal Form)...

Course

Module	Dept	Lecturer	Text
$M_1$	$D_1$	$L_1$	$T_1$
$M_1$	$D_1$	$L_1$	$T_2$
$M_2$	$D_1$	$L_1$	$T_1$
$M_2$	$D_1$	$L_1$	$T_3$
$M_3$	$D_1$	$L_2$	$T_4$
$M_4$	$D_2$	$L_3$	$T_1$
$M_4$	$D_2$	$L_3$	$T_5$
$M_5$	$D_2$	$L_4$	$T_6$

$F = \{\text{Module} \rightarrow \text{Dept}, \text{Module} \rightarrow \text{Lecturer}, \text{Lecturer} \rightarrow \text{Dept},$   
 $\{\text{Module}, \text{Text}\} \rightarrow \{\text{Dept}, \text{Lecturer}\}\}$

Here, Key: {Module, Text}

## 2NF(Second Normal Form)...

Course1

<u>Module</u>	<u>Dept</u>	<u>Lecturer</u>
$M_1$	$D_1$	$L_1$
$M_2$	$D_1$	$L_1$
$M_3$	$D_1$	$L_2$
$M_4$	$D_2$	$L_3$
$M_5$	$D_2$	$L_4$

$$F_1 = \{\text{Module} \rightarrow \{\text{Dept}, \text{Lecturer}\}, \text{Lecturer} \rightarrow \text{Dept}\}$$

Course2

<u>Module</u>	<u>Text</u>
$M_1$	$T_1$
$M_1$	$T_2$
$M_2$	$T_1$
$M_2$	$T_3$
$M_3$	$T_4$
$M_4$	$T_1$
$M_4$	$T_5$
$M_5$	$T_6$

$$F_2 = \{\{\text{Module}, \text{Text}\} \rightarrow \{\{\text{Module}, \text{Text}\}\}\}$$



## 2NF(Second Normal Form)...

***Corollary: If the primary key has a single attribute, then the relation is in 2NF***

Anomalies in 2NF Relations:

- Insertion anomalies
- Updation anomalies
- Deletion anomalies

Q:  $R=(A, B, C, D, E)$ , &  $F=\{A \rightarrow \{B, C, D, E\}, \{A, B\} \rightarrow \{C, D, E\}, C \rightarrow E, D \rightarrow E\}$

Q:  $R=(A, B, C, D, E)$ , &  $F=\{\{A, B\} \rightarrow \{C, D, E\}, B \rightarrow C, A \rightarrow D\}$

# Transitive FD

## Transitive FD

A FD  $A \rightarrow C$  is a transitive FD, if there are some set of attributes B such that  $A \rightarrow B$  and  $B \rightarrow C$  are non-trivial FDs

$A \rightarrow B$  non-trivial means B is not a subset of A

## 3NF(Third Normal Form)

### 3NF(Third Normal Form)

A relation is in 3NF iff the following two conditions are satisfied simultaneously:

- It is in 2NF
- No non-key attribute is transitively dependent on the key

The process of decomposing the non-3NF relation into 3NF relations is similar to the process of decomposing the non-2NF relation to 2NF relations

Course

Module	Dept	Lecturer
$M_1$	$D_1$	$L_1$
$M_2$	$D_1$	$L_1$
$M_3$	$D_1$	$L_2$
$M_4$	$D_2$	$L_3$
$M_5$	$D_2$	$L_4$

$F = \{\text{Module} \rightarrow \{\text{Dept}, \text{Lecturer}\}, \text{Lecturer} \rightarrow \text{Dept}\}$

This relation is not present in 3NF because  $\text{Module} \rightarrow \text{Lecturer}$  and  $\text{Lecturer} \rightarrow \text{Dept}$

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## 3NF(Third Normal Form)...

Course1

Module	Lecturer
$M_1$	$L_1$
$M_2$	$L_1$
$M_3$	$L_2$
$M_4$	$L_3$
$M_5$	$L_4$

$$F_1 = \{\text{Module} \rightarrow \text{Lecturer}\}$$

Course2

Lecturer	Dept
$L_1$	$D_1$
$L_2$	$D_1$
$L_3$	$D_2$
$L_4$	$D_2$

$$F_2 = \{\text{Lecturer} \rightarrow \text{Dept}\}$$

**Corollary: A 2NF relation is in 3NF if no non-key attribute functionally determines any other non-key attribute**

### 3NF(Third Normal Form)...

The 3NF helped us to get rid of the anomalies caused by dependencies of a non-key attribute on another non-key attribute

However, relations in 3NF are still susceptible to anomalies when the relations have two overlapping candidate keys or when non-key attribute functionally determines a key attribute.

**Overlapping candidate keys** means composite candidate keys with at least one attribute in common among themselves

***Note: A database should normally be in 3NF at least***

Q: Lecturer = (lectid, lectname, courseid, coursename) &  
F={lectid  $\rightarrow$  lectname, lectid  $\rightarrow$  courseid, lectid  $\rightarrow$  coursename, courseid  $\rightarrow$  coursename}

Q: R=(B, C, E), F= {E  $\rightarrow$  B, {B,C}  $\rightarrow$  E}

Q: Store = (order, product, customer, address, qty, unitprice) &  
F= {order  $\rightarrow$  {customer, address}, customer  $\rightarrow$  address, product  $\rightarrow$  unitprice, {order, product}  $\rightarrow$  qty}

## BCNF (Boyce-Codd Normal Form)

### BCNF (Boyce-Codd Normal Form)

A relation is in BCNF iff the following two conditions are satisfied simultaneously:

- It is in 3NF
- If for every non-trivial functional dependency, the determinant is a key

The process of decomposing the non-BCNF relation into BCNF relations is a simple process. For each non-trivial FD where the determinant is not the key, construct new relations

Student	Student	Course	Time
	Rahul	Database	12: 00
	Pratik	Database	12: 00
	Praveen	Database	15: 00
	Praveen	Programming	10: 00
	Rajib	Programming	10: 00
	Shivam	Programming	13: 00

$F = \{\{ \text{Student}, \text{Course} \} \rightarrow \text{Time}, \text{Time} \rightarrow \text{Course}, \{ \text{Student}, \text{Time} \} \rightarrow \text{Course} \}$

Key =  $\{ \text{Student}, \text{Course} \}$  and  $\{ \text{Student}, \text{Time} \}$

## BCNF (Boyce-Codd Normal Form)...

This relation is not present in BCNF as in FD  $\text{Time} \rightarrow \text{Course}$ ; the determinant  $\{\text{Time}\}$  is not a key

After the conversion of this relation to BCNF, create a new relation  $R_1 = (\underline{\text{Time}}, \text{Course})$  with set of FDs  $F_1 = \{\text{Time} \rightarrow \text{Course}\}$

The original relation is changed to  $R = (\underline{\text{Student}}, \underline{\text{Time}})$  as  $\{\text{Student}, \text{Time}\}$  set is also the key of the relation

Here, we have lost the functional dependency  $\{\text{Student}, \text{Course}\} \rightarrow \text{Time}$

## BCNF (Boyce-Codd Normal Form)...

***Corollary: If a relation has only one candidate key, then 3NF and BCNF are same. That means if a relation is in 3NF having only one candidate key, then it is also present in BCNF***

***Note: Normalization to 3NF is always lossless and dependency preserving. But, normalization to BCNF is lossless, but may not preserve all the functional dependencies***

Q:  $R = (A, B, C, D, E)$ ,  $F = \{A \rightarrow \{B, E\}, C \rightarrow D\}$ . Decompose the relation to BCNF

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Q:  $R = (A, B, C, D, E, G)$ ,  $F = \{\{A, B\} \rightarrow \{C, D\}, \{B, C\} \rightarrow \{D, A\}, C \rightarrow G, B \rightarrow E\}$ . Decompose this relation to BCNF

Q:  $R = (A, B, C, D)$  &  $F = \{\{A, C\} \rightarrow \{B, D\}, \{B, C\} \rightarrow \{D, A\}, A \rightarrow B, B \rightarrow A\}$ . Decompose this relation to BCNF