



## DATABASE NORMALIZATION

**Primary Key** - A primary key is a column (or columns) in a table that uniquely identifies the rows in that table.

For example -

*Employee(Employee\_id, Employee\_name, Department\_id)*

In this table *Emp\_id* is the primary key.

The value placed in primary key columns must be unique for each row : no duplicates can be tolerated. In addition, nulls are not allowed in primary key columns.

**Foreign Key** - Foreign keys are columns that point to primary key columns.

For example -

*Employee(Employee\_id, Employee\_name, Department\_id)*

*Department(Department\_id, Department\_name, Total\_Employee)*

*Employee\_id* is the primary key of the table *Employee* and *Department\_id* is the primary key of the table *Department* but in *Employee* table *Department\_id* is the foreign key that points to the primary key in the *Department* table.

## FIRST NORMAL FORM (1NF)

- There is no duplicate rows or tuples in the relation.
- Each data field can contain only one value.
- Entries in a column (attribute) are of the same kind (type).

Example -

**Table Name : Office**

Department_id	Department_name	Employee_id	Employee_name	Salary
D-100	PHP	E-1001	Mr. A	30000
		E-1005	Mr. B	28000
		E-1008	Mr. C	25000
D-200	JAVA	E-1002	Mr. X	25000
		E-1004	Mr. Y	30000
		E-1006	Mr. Z	20000
D-300	Admin	E-1003	Mr. D	20000
		E-1007	Mr. E	30000

Table "office" not in first normal form, because in this table many data field contain multiple values, so it is require to convert into first normal form.

**Table Name : Office**

Department_id	Department_name	Employee_id	Employee_name	Salary
D-100	PHP	E-1001	Mr. A	30000
D-100	PHP	E-1005	Mr. B	28000
D-100	PHP	E-1008	Mr. C	25000
D-200	JAVA	E-1002		

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D-200	JAVA	E-1004	Mr. Y	30000
D-200	JAVA	E-1006	Mr. Z	20000
D-300	Admin	E-1003	Mr. D	20000
D-300	Admin	E-1007	Mr. E	30000

SECOND NORMAL FORM (2NF)

A relation is in 2NF if it is in 1NF and every non-key attribute is fully dependent on each candidate key of the relation. That means in second normal form each table have only one entity which uniquely identify other entities. This particular entity contain only primary key value. In another way we can say that if there is more than one primary key then the table is required to convert into second normal form.

Example -  
The "Office" table which shown in First Normal Form is require to convert into Second Normal Form.

Functional Dependecy in "Office" Table  
*(Department\_id, Employee\_id) → (Department\_name, Employee\_name, Salary)*

Partial Dependecy in "Office" Table  
*Department\_id → Department\_name*  
*Employee\_id → (Employee\_name, Salary)*

After 2NF the "Office" table is divided into two tables which are :

Table Name : *Employee*

Employee_id	Employee_name	Salary	Department_id
E-1001	Mr. A	30000	D-100
E-1005	Mr. B	28000	D-100
E-1008	Mr. C	25000	D-100
E-1002	Mr. X	25000	D-200
E-1004	Mr. Y	30000	D-200
E-1006	Mr. Z	20000	D-200
E-1003	Mr. D	20000	D-300
E-1007	Mr. E	30000	D-300

Table Name : *Department*

Department_id	Department_name
D-100	PHP
D-200	JAVA
D-300	Admin

THIRD NORMAL FORM (3NF)

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A relation is in third normal form if it is in 2NF and every non-key attribute of the relation is non-transitively dependent on each candidate key of the relation.

Example -  
*Library(Book\_id, Book\_name, Author\_name, Bookshelf\_number, Book\_category)*

Functional Dependency  
*book\_id* → (*Book\_name, Author\_name, Bookshelf\_number, Book\_category*)

Transitive Dependency  
*Bookshelf\_number* → *Book\_category*

Table Name : *Library*

Book_id	Book_name	Author_name	Bookshelf_number	Book_category
B-100	Hacking Sectrets Exposed	Srikanth Ramesh	10	Hacking
B-105	The Complete Reference C++	Herbert Schildt	30	C and C++
B-200	Linux Shell Scripting with Bash	Ken O. Burtch	40	Linux
B-250	The Basics of Web Hacking	Josh Pauli	10	Hacking
B-350	Database System Concepts	Silberschatz Korth Sudarshan	20	DBMS
B-480	Shell Scripting	Steven Parker	40	Linux
B-610	The Complete Reference Java	Herbert Schildt	50	JAVA
B-750	Penetration Testing with the Bash Shell	Keith Makan	40	Linux

Table "Library" not in third normal form, because a transitive dependency present in this table.

Table Name : *Book*

Book_id	Book_name	Author_name	Bookshelf_number
B-100	Hacking Sectrets Exposed	Srikanth Ramesh	10
B-105	The Complete Reference C++	Herbert Schildt	30
B-200	Linux Shell Scripting with Bash	Ken O. Burtch	40
B-250	The Basics of Web Hacking	Josh Pauli	10
B-350	Database System Concepts	Silberschatz Korth Sudarshan	20
B-480	Shell Scripting	Steven Parker	40
B-610	The Complete Reference Java	Herbert Schildt	50
B-750	Penetration Testing with the Bash Shell	Keith Makan	40

Table Name : *Bookshelf*

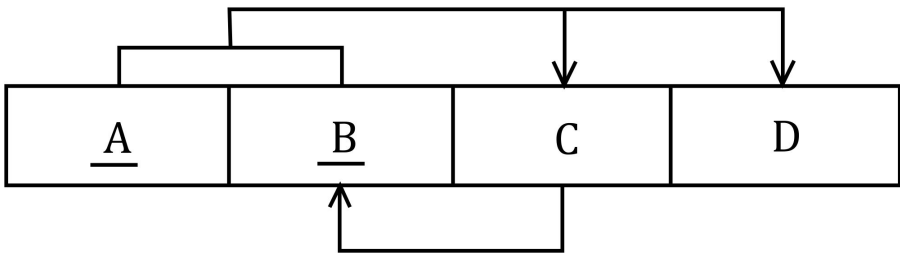
Bookshelf_number	Book_category
10	Hacking
20	DBMS
30	C and C++
40	Linux
50	JAVA

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BOYCE CODE NORMAL FORM (BCNF)

A table is in BCNF when every determinant in the table is a candidate key. Clearly when a table contains only one candidate key the 3NF and the BCNF are equivalent. Putting that proposition another way, BCNF can be violated only when the table contains more than one candidate key.

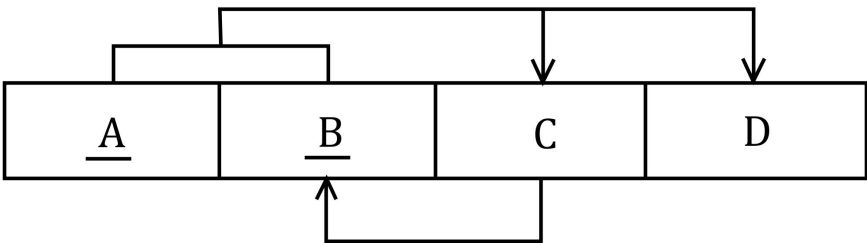
The table is in 3NF but not in BCNF



Functional Dependencies  
 $(A, B) \rightarrow (C, D)$   
 $C \rightarrow B$

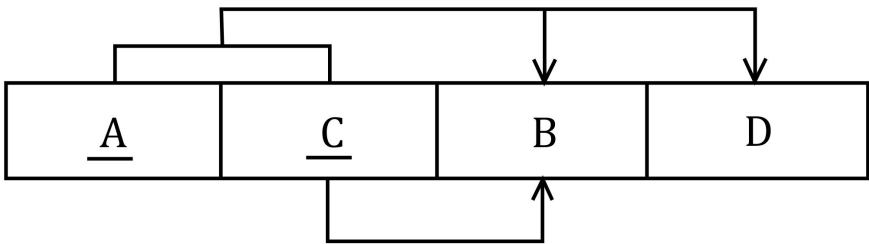
Notice that this structure has two candidate keys : (A,B) and (A,C). The table structure shown in above figure has no partial dependencies, nor does it contain transitive dependencies. (The condition  $C \rightarrow B$  indicated that a non-key attribute determines part of the primary key - and that dependency is not transitive or partial because the dependent is a prime attribute!). Thus the table structure in the above figure is in 3NF but not in BCNF.

Step 1



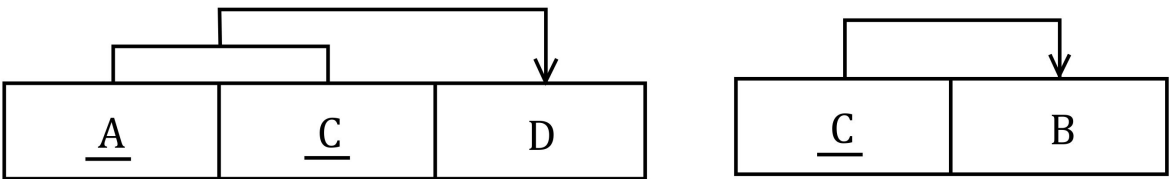
The table is in 3NF but not in BCNF

Step 2



Partial Dependency

Step 3



3NF and BCNF

3NF and BCNF

Example -  
*Class\_Test(Student\_id, Professor\_id, Class\_code, Student\_grade)*

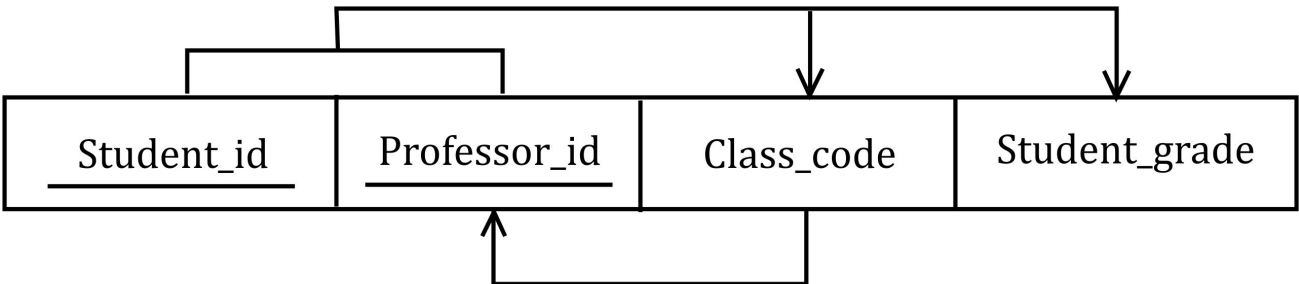
Functional Dependency  
 $(Student\_id, Professor\_id) \rightarrow (Class\_code, Student\_grade)$   
 $Class\_code \rightarrow Professor\_id$

Table Name : *Class\_Test*

Student_id	Professor_id	Class_code	Student_grade
S-10001	P-100	C-1001	
S-10001	P-300	C-1002	

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S-10002	P-100	C-1001	C
S-10002	P-200	C-1003	C
S-10003	P-100	C-1005	A
S-10004	P-100	C-1001	B
S-10004	P-200	C-1003	A
S-10005	P-100	C-1004	A



The table is in 3NF but not in BCNF

The table reflects the following conditions :

- Each "Student\_id" identifies a student uniquely.
- Each "Professor\_id" identifies a professor uniquely.
- Each "Class\_code" identifies a class uniquely.
- A student can take many classes. For example - Student "S-10001" attend both classes "C-1001" and "C-1002".
- A professor can teach many classes but each class is taught by only one professor. For example - Professor "P-100" teaches the classes "C-1001" and "C-1004". (So, the "Professor\_id" can identify by the "Class\_code" not vice versa.)
- If a new professor is assigned to teach class "C-1001", three rows will require updates, thus producing an update anomaly.
- If student "S-10003" drops class "C-1005", information about wqho taught class is lost, thus producing a deletion anomaly.

Table Name : *Grade*

Student_id	Class_code	Student_grade
S-10001	C-1001	A
S-10001	C-1002	B
S-10002	C-1001	C
S-10002	C-1003	C
S-10003	C-1005	A
S-10004	C-1001	B
S-10004	C-1003	A
S-10005	C-1004	A

Table Name : *Class*

Class_code	Professor_id
C-1001	P-100
C-1002	P-300
C-1003	P-200
C-1004	P-100
C-1005	P-100

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FOURTH NORMAL FORM (4NF)

Fourth Normal Form is related to Multi-value Dependency. Under fourth normal form, a record type should not contain two or more independent multi-value facts about an entity. In addition the record must satisfy third normal form.

A multi-value dependency exists when

- There are at least three attributes A, B and C in a relation.
- For each value of A there is a well-defined set of values for B, and a well-defined set of values for C.
- The set of values of B is independent of set C.

If a table in 4NF then -

- All attributes must be dependent on the primary key, but they must be independent of each other.
- No row may contain two or more multivalued facts about an entity.

Example -

Course(Course\_code, Professor, Reference\_book)

Multivalue Dependency

Course\_code → → Professor

Course\_code → → Reference\_book

Table Name : Course

Course_code	Professor	Reference_book
C-100	Mr. X	The TCP/IP Guide (Charles M. Kozierok)
C-100	Mr. Y	The TCP/IP Guide (Charles M. Kozierok)
C-200	Mr. A	Linux Shell Scripting with Bash (Ken O. Burtch)
C-200	Mr. A	Shell Scripting (Steven Parker)
C-200	Mr. A	Penetration Testing with the Bash Shell (Keith Makan)
C-200	Mr. B	Linux Shell Scripting with Bash (Ken O. Burtch)
C-300	Mr. C	Hacking Sectrets Exposed (Srikanth Ramesh)
C-300	Mr. D	Hacking Sectrets Exposed (Srikanth Ramesh)
C-300	Mr. D	The Basics of Web Hacking (Josh Pauli)
C-400	Mr. E	Database System Concepts (Silberschatz Korth Sudarshan)

The table reflects the following conditions :

- A course can be taught by one or many professor but each professor can teach only one course. For example - Course "C-100" taught by the professors "Mr. X" and "Mr. Y". (So, Course\_code → → Professor)
- A professor can refer one or many textbook for a particular course.
- A textbook can be refer by one or many professor allocated for a particular course.
- Textbooks refer for a particular course can not be refer for another course. (So, Course\_code → → Reference\_book)

Table Name : Instructor

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Course_code	Professor
C-100	Mr. X
C-100	Mr. Y
C-200	Mr. A
C-200	Mr. B
C-300	Mr. C
C-300	Mr. D
C-400	Mr. E

Table Name : *Textbook*

Course_code	Reference_book
C-100	The TCP/IP Guide (Charles M. Kozierok)
C-200	Linux Shell Scripting with Bash (Ken O. Burtch)
C-200	Shell Scripting (Steven Parker)
C-200	Penetration Testing with the Bash Shell (Keith Makan)
C-300	Hacking Sectrets Exposed (Srikanth Ramesh)
C-300	The Basics of Web Hacking (Josh Pauli)
C-400	Database System Concepts (Silberschatz Korth Sudarshan)

FIFTH NORMAL FORM (5NF)

A table is in Fifth Normal Form (5NF) or Project-Join Normal Form (PJNF) if it is in 4NF and it can not have a lossless decomposition into any number of smaller tables.

The fifth normal form deals with join-dependencies, which is a generalisation of the multi-value dependency.

Table Name : *Project\_details*

Employee_id	Project_name	programming_Language
E-100	Google	Laravel
E-100	Facebook	PHP
E-200	Facebook	PHP
E-200	Google	CakePHP
E-200	Yahoo	CakePHP
E-300	Yahoo	Laravel

Table Name : *Project*

Employee_id	Project_name
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E-100	Google
E-100	Facebook
E-200	Facebook
E-200	Google
E-200	Yahoo
E-300	Yahoo

Table Name : *Language*

Employee_id	programming_Language
E-100	Laravel
E-100	PHP
E-200	PHP
E-200	CakePHP
E-300	Laravel

Table Name : *Project\_Language*

Project_name	programming_Language
Google	Laravel
Facebook	PHP
Google	CakePHP
Yahoo	CakePHP
Yahoo	Laravel

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