BOYCE CODD NORMAL FORM (BCNF)

- BCNF is the advance version of 3NF. It is stricter than 3NF.
- A table is in BCNF if every functional dependency X → Y, X is the super key of the table.
- For BCNF, the table should be in 3NF, and for every FD, LHS is super key.

Example: Let's assume there is a company where employees work in more than one department.

EMPLOYEE table:

EMP_ID	EMP_COUNTRY	EMP_DEPT	DEPT_TYPE	EMP_DEPT_NO
264	India	Designing	D394	283
264	India	Testing	D394	300
364	UK	Stores	D283	232
364	UK	Developing	D283	549

In the above table Functional dependencies are as follows:

1. EMP_ID → EMP_COUNTRY
2. EMP_DEPT → {DEPT_TYPE, EMP_DEPT_NO}

Candidate key: {EMP-ID, EMP-DEPT}

The table is not in BCNF because neither EMP_DEPT nor EMP_ID alone are keys.

To convert the given table into BCNF, we decompose it into three tables:

EMP_COUNTRY table:

EMP_ID	EMP_COUNTRY
264	India
264	India

EMP_DEPT table:

EMP_DEPT	DEPT_TYPE	EMP_DEPT_NO
Designing	D394	283
Testing	D394	300
Stores	D283	232
Developing	D283	549

EMP_DEPT_MAPPING table:

EMP_ID	EMP_DEPT
D394	283
D394	300
D283	232
D283	549

Functional dependencies:

1. EMP_ID → EMP_COUNTRY
2. EMP_DEPT → {DEPT_TYPE, EMP_DEPT_NO}

Candidate keys:

For the first table: EMP_ID

For the second table: EMP_DEPT

For the third table: {EMP_ID, EMP_DEPT}

Now, this is in BCNF because left side part of both the functional dependencies is a key.

Example 2:

Let us see another one example:

Below we have a college enrolment table with columns student_id, subject and professor.

student_id	subject	professor
101	Java	P.Java
101	C++	P.Cpp
102	Java	P.Java2
103	C#	P.Chash
104	Java	P.Java

As you can see, we have also added some sample data to the table.

In the table above:

- One student can enrol for multiple subjects. For example, student with **student_id** 101, has opted for subjects - Java & C++
- For each subject, a professor is assigned to the student.
- And, there can be multiple professors teaching one subject like we have for Java.

What do you think should be the Primary Key?

- Well, in the table above student_id, subject together form the primary key, because using student_id and subject, we can find all the columns of the table.
- One more important point to note here is, one professor teaches only one subject, but one subject may have two different professors.
- Hence, there is a dependency between subject and professor here, where subject depends on the professor name.
- This table satisfies the **1st Normal form** because all the values are atomic, column names are unique and all the values stored in a particular column are of same domain.
- This table also satisfies the **2nd Normal Form** as their is no **Partial Dependency**.
- And, there is no **Transitive Dependency**, hence the table also satisfies the **3rd Normal Form**.

But this table is not in **Boyce-Codd Normal Form**.

Why this table is not in BCNF?

In the table above, student_id, subject form primary key, which means subject column is a **prime attribute**.

But, there is one more dependency, professor → subject.

And while subject is a prime attribute, professor is a **non-prime attribute**, which is not allowed by BCNF.

How to satisfy BCNF?

To make this relation(table) satisfy BCNF, we will decompose this table into two tables, **student** table and **professor** table.

Below we have the structure for both the tables.

Student Table

student_id	p_id
101	1
101	2
and so on...	

And, **Professor Table**

p_id	professor	subject
1	P.Java	Java
2	P.Cpp	C++

and so on...

And now, this relation satisfy Boyce-Codd Normal Form.