Normal forms
BCNF (Boyce-Codd Normal Form)

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- Conditions for BCNF

BCNF is **based on the concept of a determinant**.

Primary Key — Determinant — Dependent

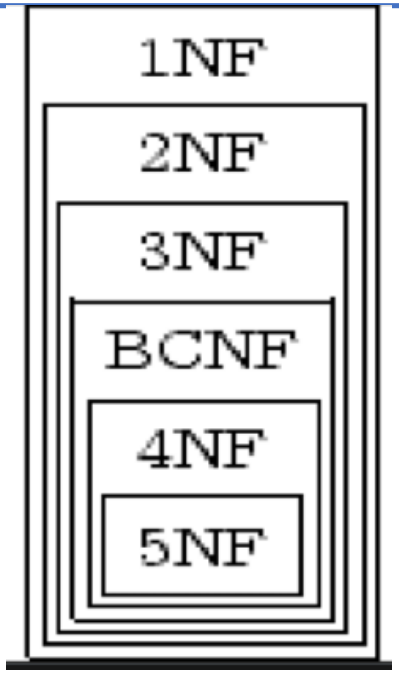
AccountNO → {Balance, Branch}

It is in **3NF** and **every determinant should be key**.

- A relation R is in Boyce-Codd normal form (BCNF)
  1. if and only if it is in 3NF and
  2. for every F.D. of the form X → Y, either Y is proper subset of X (i.e. Trivial F.D.) or X is a key.

OR

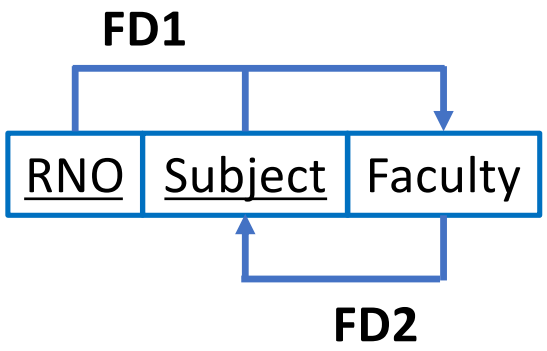
- A relation R is in Boyce-Codd normal form (BCNF)
  1. if and only if it is in 3NF and
  2. no any prime key attribute is transitively dependent on the key



BCNF (Boyce-Codd Normal Form) [Example]

Student

RNO	Subject	Faculty
101	DS	Patel
102	DBMS	Shah
103	DS	Jadeja
104	DBMS	Dave
105	DBMS	Shah
102	DS	Patel
101	DBMS	Dave
105	DS	Jadeja



- **FD1**: RNO, Subject → Faculty
- **FD2**: Faculty → Subject
- So {RNO, Subject} → Subject (Transitivity rule)

In FD2, **determinant is Faculty which is not a primary key**. So student table is not in BCNF.

Problem: In this relation **one student can learn more than one subject with different faculty** then **records will be stored repeatedly for each student, language and faculty combination** which **occupies more space**.

- Here, one faculty teaches only one subject, but a subject may be taught by more than one faculty.
- A student can learn a subject from only one faculty.

BCNF (Boyce-Codd Normal Form) [Example]

Student

RNO	Subject	Faculty
101	DS	Patel
102	DBMS	Shah
103	DS	Jadeja
104	DBMS	Dave
105	DBMS	Shah
102	DS	Patel
101	DBMS	Dave
105	DS	Jadeja

Table-1

Faculty	Subject
Patel	DS
Shah	DBMS
Jadeja	DS
Dave	DBMS

Table-2

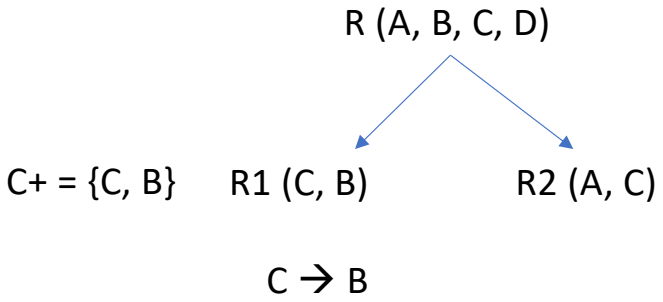
RNO	Faculty
101	Patel
102	Shah
103	Jadeja
104	Dave
105	Shah
102	Patel
101	Dave
105	Jadeja

- **Solution**: Decompose relation in such a way that resultant relations do not have any transitive FD.
  - Remove transitive dependent prime attribute from relation that violets BCNF.
  - Place them in separate new relation along with the non-prime attribute due to which transitive dependency occurred.
  - The primary key of new relation will be this non-prime attribute due to which transitive dependency occurred.
  - Keep other attributes same as in that table with same primary key and add a prime attribute of other relation into it as a foreign key.

Q. 1 Given that R (A, B, C) & FD {AB → C, C → B}. Check whether it is in BCNF or not, if not, then convert it into BCNF.

Key = {AB, AC}.

C → B violates BCNF rule.



i. Lossless (Yes)

ii. Dependency preserving (May be)

Normal forms
(Exercises)

Find (candidate) key & check for normal forms [Example]

- Suppose you are given a relation R with four attributes ABCD. For each of the following sets of FDs, do the following: **F = (B → C, D → A)**
  - Identify the candidate key(s) for R.
  - Identify the best normal form that R satisfies (1NF, 2NF, 3NF or BCNF).

Candidate Key is BD

Relation R is in 1NF but not 2NF. In above FDs, there is a partial dependency

(As per FD B → C, C depends only on B but Key is BD so C is partial depends on key (BD))

(As per FD D → A, A depends only on D but Key is BD so A is partial depends on key (BD))

Find (candidate) key & check for normal forms [Example]

- Suppose you are given a relation R with four attributes ABCD. For each of the following sets of FDs, do the following: **F = (C → D, C → A, B → C)**
  - Identify the candidate key(s) for R.
  - Identify the best normal form that R satisfies (1NF, 2NF, 3NF or BCNF).

Candidate Key is B

Relation R is in 2NF but not 3NF. In above FDs, there is a transitive dependency

(As per FDs B → C & **C → D** then **B → D** so D is transitive depends on key (B))

(As per FDs B → C & C → A then B → A so **A is transitive depends on key (B)**)

Find (candidate) key & check for normal forms [Example]

- Suppose you are given a relation R with four attributes ABCD. For each of the following sets of FDs, do the following: **F = (A → B, BC → D, A → C)**
  - Identify the candidate key(s) for R.
  - Identify the best normal form that R satisfies (1NF, 2NF, 3NF or BCNF).

Candidate Key is A

Relation R is in 2NF but not 3NF. In above FDs, there is a transitive dependency

(As per FDs A → B & **A → C** then **A → BC** using union rule) and

(As per FDs A → BC & BC → D then A → D so **D is transitive depends on key (A)**)

Find (candidate) key & check for normal forms [Example]

- Suppose you are given a relation R with four attributes ABCD. For each of the following sets of FDs, do the following: **F = (ABC → D, D → A)**
  - Identify the candidate key(s) for R.
  - Identify the best normal form that R satisfies (1NF, 2NF, 3NF or BCNF).

Candidate Key are ABC & BCD

Relation R is in 3NF but not BCNF.

In the above FDs, both FDs have prime attribute **(D and A)** in dependent (right) side.

Normal Form [Exercise]

Q.) R (A, B, C, D, E), **F = (AB → CE, E → AB, C → D,** Identify the highest normal form.

Q.) R (X, Y, Z, W), **F = (X → W, W → X, XY → Z,** Identify the highest normal form.