Fourth Normal Form

Fourth Normal Form (4NF)

- Although BCNF removes anomalies due to functional dependencies, another type of dependency called a multi-valued dependency (MVD) can also cause data redundancy.

- Possible existence of multi-valued dependencies in a relation is due to 1NF and can result in data redundancy.

Fourth Normal Form (4NF)

- Multi-valued Dependency (MVD)

  - Dependency between attributes (for example, A, B, and C) in a relation, such that for each value of A there is a set of values for B and a set of values for C. However, the set of values for B and C are independent of each other.

Fourth Normal Form (4NF)

- MVD between attributes A, B, and C in a relation using the following notation:

  A ->> B

  A ->> C

Fourth Normal Form (4NF)

- Now consider the table (CourseStudentBook) involving course, studentName and textBook.

course	studentName	textBook
Database Design	Anne Greene	Basic Databases
Database Design	Anne Greene	Basic Data Modelling
Mathematics	Tim Power	Introduction to Maths
Mathematics	John Daly	Introduction to Maths
Mathematics	Ben Keane	Introduction to Maths
Mathematics	Tim Power	Basic Maths
Mathematics	John Daly	Basic Maths
Mathematics	Ben Keane	Basic Maths

CourseStudentBook

Fourth Normal Form (4NF)

- Suppose a course can have many texts books and a course can have many students, but the students are independent of the text books. In other words the text books are associated with the course code regardless of who is being taught. Likewise the students are associated with the course code regardless of the textbooks.

- Thus text books and students are independent sets but both are determined by the course code.

- Two independent 1:* relationships are represented in the same relation:

  - course —>> studentName

  - course —>> textBook

Anomalies of relations with MVDs

- This form of the table is obviously full of anomalies. If a new student join the Mathematics course. we have to make two insertions for that student in the database, which is equal to the number of Mathematics textbooks. Consider the problem if there are hundred textbooks for a subject. Similarly, if a new textbook is introduced for a course, then again we have to make multiple insertions in the database, which is equal to number of students for that course. So, there is a high degree of redundancy in the database, which will lead to update problems.

Anomalies of relations with MVDs

- **A relation is in fourth normal form if and only if it is in BCNF and does not contain nontrivial multi-valued dependencies.**

- A MVD A ->> B in relation R is defined as being trivial if
  - (a) B is a subset of A (A, B $\rightarrow$ A) or
  - (b) A U B = R.

- Under fourth normal form, a record type should not contain two or more independent multi-valued facts about an entity.

- The normalisation of a relation breaking the 4NF rule requires the removal of the offending MVD from the relation by placing the multi-valued attribute(s) in a new relation along with a copy of the determinant.

Rule to transform a relation into Fourth Normal Form

- A relation R having A, B, and C, as attributes can be non loss-decomposed into two projections R1(A,B) and R2(A,C) if and only if the MVD −>> B|C hold in R.

- Looking again at the un-decomposed COURSESTUDENTBOOK table, it contains a multi-valued dependency as shown below:

- course −>> studentName

- course −>> textBook

Rule to transform a relation into Fourth Normal Form

- To put the table into 4NF, two separate tables are formed as shown below:

  COURSESTUDENT (course, studentName)
  Primary key course, studentName

  COURSEBOOK (course, textBook)
  Primary key course, textBook

Exercise

- Now consider the table (BranchStaffOwner) involving branchNo, sName and oName.

- The table lists PropertyForRent branches, the staff (by name) who work there and the owners (by name) who have properties for rent there.

BranchStaffOwner

branchNo	sName	oName
B003	Ann Beech	Carol Farrel
B003	David Ford	Carol Farrel
B003	Ann Beech	Tina Murphy
B003	David Ford	Tina Murphy

Exercise

- The relation (BranchStaffOwner) is not in Fourth Normal Form)

    i. Why?

    ii. Explain the steps involved in transforming the relation into Fourth Normal Form (4NF).

    iii. Transform the relation into a set of Fourth Normal Form (4NF) relations.

Exercise