



4 NF

Overview

- Multi-valued Dependencies
- Fourth Normal Form – 4NF

Multivalued Dependency

- Multivalued dependencies are consequence of first normal form (1NF) – disallowed set of values for an attribute in a tuple.
- MVD is a consequence of two or more multivalued *independent* attributes in the same relation.
- Informally whenever two *independent* 1:N relationships A:B and A:C are mixed in the same relation, an MVD may arise.

Multivalued Dependency

- Multi-valued dependence:

Let R be a relvar, and let A,B, and C be subsets of the attributes of R. Then we say that B is multi-dependent on A – in symbols,

$A \twoheadrightarrow B$ [A **multi-determines** B]

if and only if, in every legal value of R, the set of B values matching a given AC value pair depends only on the A and is independent of the C value.

Fagin Theorem

- Given a relvar $R\{A,B,C\}$, the MVD $A \twoheadrightarrow B$ holds if and only if the MVD $A \twoheadrightarrow C$ also holds.
- Then to represent both: $A \twoheadrightarrow B \mid C$

Theorem (Fagin):

Let $R\{A,B,C\}$ be a relvar, where A, B , and C are sets of attributes. Then R is equal to the join of its projections on $\{A,B\}$ and $\{A,C\}$ if and only if R satisfies the MVDs: $A \twoheadrightarrow B \mid C$

MVDs and Fourth NF

- (a) The EMP relation with two MVDs: $\text{ENAME} \twoheadrightarrow \text{PNAME}$ and $\text{ENAME} \twoheadrightarrow \text{DNAME}$.
- (b) Decomposing the EMP relation into two 4NF relations EMP_PROJECTS and EMP_DEPENDENTS.

(a)

<u>ENAME</u>	PNAME	<u>DNAME</u>
Smith	X	John
Smith	Y	Anna
Smith	X	Anna
Smith	Y	John

(b)

<u>ENAME</u>	<u>PNAME</u>
Smith	X
Smith	Y

<u>ENAME</u>	<u>DNAME</u>
Smith	John
Smith	Anna

Fourth Normal Form – 4NF

Fourth Normal Form:

Relvar R is in 4NF if and only if, whenever there exist subsets A and B of the attributes of R such that the *nontrivial* MVD $A \twoheadrightarrow B$ is satisfied, then all attributes of R are also functionally dependent on A.

An MVD $X \twoheadrightarrow Y$ in R is called a **trivial MVD** if

(a) Y is a subset of X, or (b) $X \cup Y = R$.

Fourth Normal Form – 4NF

Decomposing a relation state of EMP that is not in 4NF:

- (a) EMP relation with additional tuples.
- (b) Two corresponding 4NF relations EMP_PROJECTS and EMP_DEPENDENTS.

(a) **EMP**

<u>ENAME</u>	<u>PNAME</u>	<u>DNAME</u>
Smith	X	John
Smith	Y	Anna
Smith	X	Anna
Smith	Y	John
Brown	W	Jim
Brown	X	Jim
Brown	Y	Jim
Brown	Z	Jim
Brown	W	Joan
Brown	X	Joan
Brown	Y	Joan
Brown	Z	Joan
Brown	W	Bob
Brown	X	Bob
Brown	Y	Bob
Brown	Z	Bob

(b) **EMP_PROJECTS**

<u>ENAME</u>	<u>PNAME</u>
Smith	X
Smith	Y
Brown	W
Brown	X
Brown	Y
Brown	Z

EMP_DEPENDENTS

<u>ENAME</u>	<u>DNAME</u>
Smith	Anna
Smith	John
Brown	Jim
Brown	Joan
Brown	Bob

References

- *Chapter 11: Functional Dependencies*
An introduction to database systems, *CJ. Date*

