Functional Dependencies

- ***Definition of Functional Dependency***
- A functional dependency is a constraint between two sets of attributes from the database.
- **EXAMPLE:**
- Suppose that our relational database schema has n attributes A1, A2,… , An; let us think of the whole database as being described by a single universal relation schema

  R = {A1, A2, … , An}.
- **Definition:**
  - **A functional dependency, denoted by X → Y, between two sets of attributes X and Y that are subsets of R specifies a constraint on the possible tuples that can form a relation state r of R.**
  - **The constraint is that, for any two tuples t1 and t2 in r that have t1[X] = t2[X], they must also have t1[Y] = t2[Y].**

Functional Dependencies

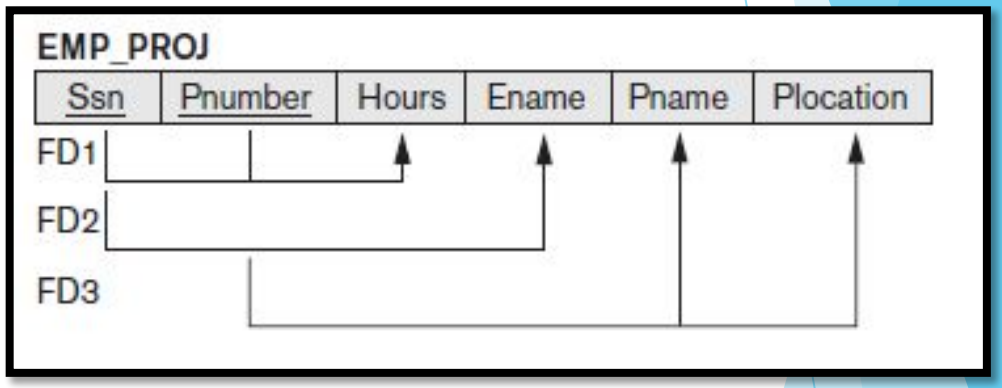
- ***Definition of Functional Dependency***
- **EXAMPLE:**
- This means that the values of the **Y component of a tuple in r depend on, or are determined by, the values of the X component;** alternatively, the values of the X component of a tuple uniquely (or functionally) determine the values of the Y component.
- We also say that there is a **functional dependency from X to Y, or that Y is functionally dependent on X.**
- The abbreviation for functional dependency is **FD or f.d**.
- The set of attributes **X is called the left-hand side** of the FD, and Y is called the **right-hand side**.

Functional Dependencies

- ***Definition of Functional Dependency***
- Note the following:
- If a constraint on R states that there cannot be more than one tuple with a given X-value in any relation instance r(R)—that is, X is a candidate key of **R—this implies that X → Y for any subset of attributes Y of R (because the key constraint implies that no two tuples in any legal state r(R) will have the same value of X).** If X is a candidate key of R, then X → R.
- If X → Y in R, this does not say whether or not Y → X in R.

Functional Dependencies

- ***Definition of Functional Dependency***
- Consider the relation schema EMP_PROJ in Figure 14.3(b); from the semantics of the attributes and the relation, we know that the following functional dependencies should hold:
- **a. Ssn → Ename**
- **b. Pnumber → {Pname, Plocation}**
- **c. {Ssn, Pnumber} → Hours**



- These functional dependencies specify that:
  - (a) the value of an employee's Social Security number (Ssn) uniquely determines the employee name (Ename),
  - (b) the value of a project's number (Pnumber) uniquely determines the project name (Pname) and location (Plocation),
  - (c) a combination of Ssn and Pnumber values uniquely determines the number of hours the employee currently works on the project per week (Hours).

Functional Dependencies

TEACH

Teacher	Course	Text
Smith	Data Structures	Bartram
Smith	Data Management	Martin
Hall	Compilers	Hoffman
Brown	Data Structures	Horowitz

- ***Definition of Functional Dependency***
- A functional dependency is a property of the relation schema R, not of a particular legal relation state r of R.
- For example, Figure 14.7 shows a particular state of the TEACH relation schema.
- We may think that **Text → Course**, we cannot confirm this unless we know that it is true for all possible legal states of TEACH.
- For example, because 'Smith' teaches both 'Data Structures' and 'Database Systems,' we can conclude that **Teacher does not functionally determine Course**.

Functional Dependencies

- ***Definition of Functional Dependency***
- Here, the following FDs may hold because the four tuples in the current extension have no violation of these constraints:
- **B → C;**
- **C → B;**
- **{A, B} → C;**
- **{A, B} → D;**
- **{C, D} → B**

A	B	C	D
a1	b1	c1	d1
a1	b2	c2	d2
a2	b2	c2	d3
a3	b3	c4	d3

- However, the following do not hold because we already have violations of them in the given extension:
- **A → B**
- **B → A**
- **D → C**

Functional Dependencies

Sample Relation

A	B	C	D	E
a	b	z	w	q
e	b	r	w	p
a	d	z	w	t
e	d	r	w	q
a	f	z	s	t
e	f	r	s	t

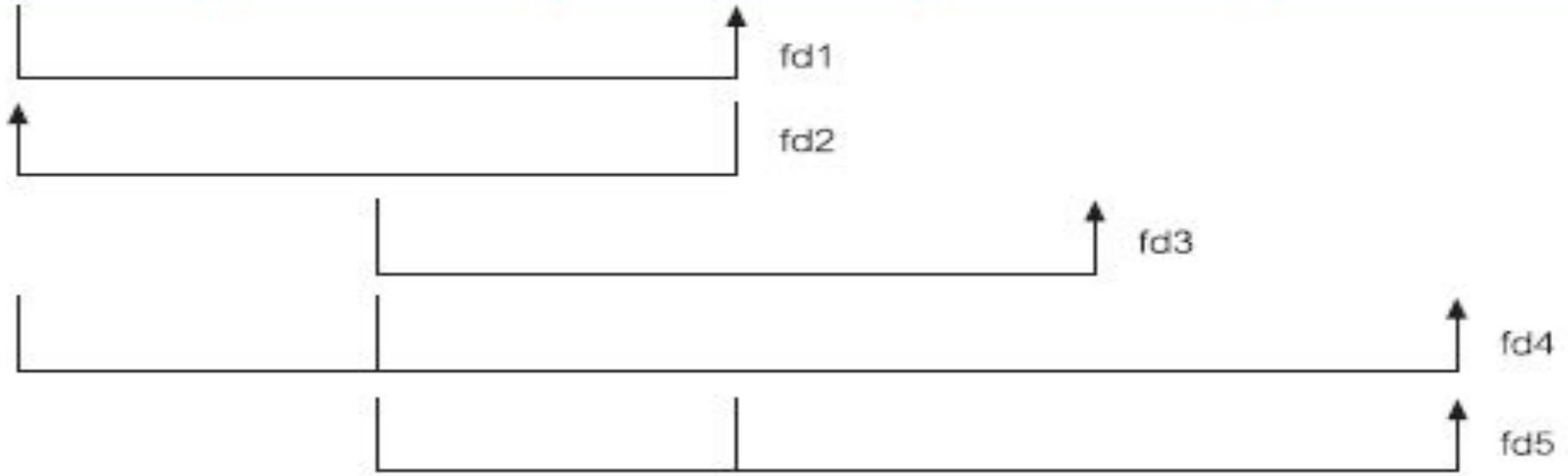
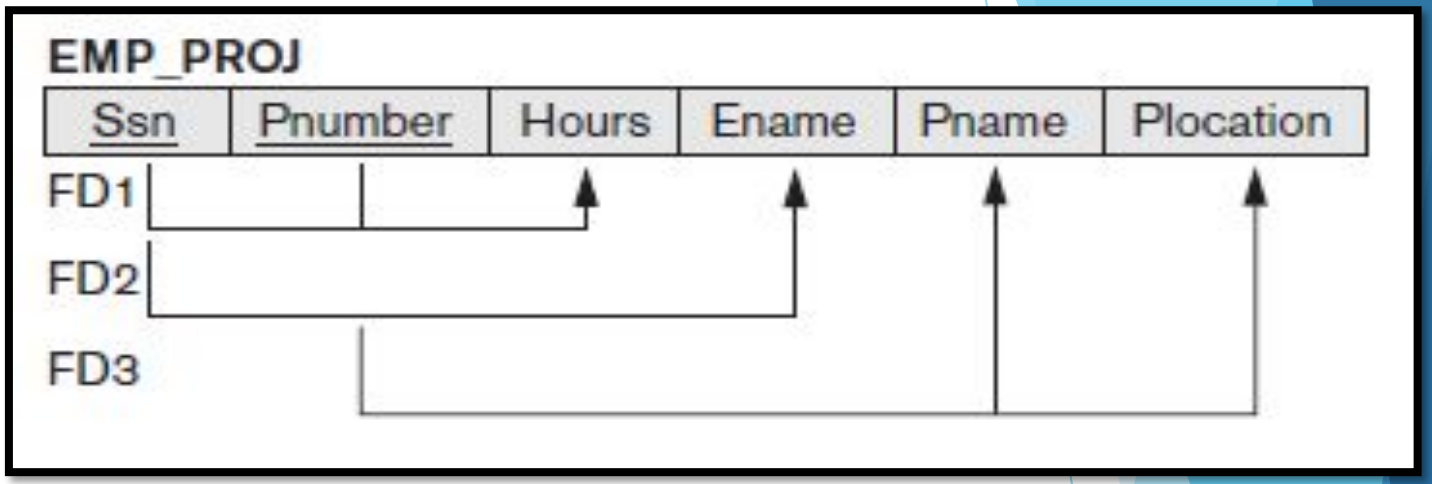


Figure 14.6 The Sample relation displaying data for attributes A, B, C, D, and E and the functional dependencies (fd1 to fd5) that exist between these attributes.

Functional Dependencies



- *Definition of Functional Dependency*
- Figure 14.3
  - diagrammatic notation for displaying FDs
  - Each FD is displayed as a horizontal line.
- The left-hand-side attributes of the FD are connected by vertical lines to the line representing the FD,
- The right-hand-side attributes are connected by the lines with arrows pointing toward the attributes.

Properties of Functional Dependencies

- ***Reflexivity***
  - *If* X → Y & y is the subset of X , then X → X
  - An attribute determines itself
  - Always valid
  - Trivial FD
- ***Transitivity***
  - *If (*X → Y & Y → Z), then X → Z (might or might not be valid if any one of the condition in if case is false)
- ***Augmentation***
  - *If (*X → Y), then XA → YA
- ***Union***
  - *If (*X → Y & X → Z), then X → YZ
- ***Decomposition***
  - *If (*X → YZ), then X → Y , X → Z
  - Converse is not true
- ***Pseudo Transitivity***
  - *If (*X → Y & YZ → A), then XZ → A
- ***Composition***
  - If (X → Y & A → B), then XA → YB

Roll No	Name	Marks	Department	Course
1	Maryam	78	CS	OOP
2	Maira	60	AI	OOP
3	Maryam	78	CS	DB
4	Maira	60	AI	ML
5	Mohammad	80	SE	DB