Database Management Systems

ICT1212

Introduction to Normalization Using Functional and Multivalued Dependencies

Department of ICT
Faculty of Technology
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Lecture 9

What we are discussing

- Informal Design Guidelines for Relational Databases
- Functional Dependencies (FDs)
- Normal Forms
  - 1NF
  - 2NF
  - 3NF
  - BCNF
  - 4NF
  - 5NF

Goodness of Relation Schemas

- What is relational database design?
  - The grouping of attributes to form "good" relation schemas
- Two levels of relation schemas
  - The logical "user view" level
  - The storage "base relation" level
- Design is concerned mainly with base relations

Goodness of Relation Schemas

- There are two levels at which we can discuss the *goodness* of relation schemas
- **logical** (or **conceptual**) **level**
  - How users interpret the relation schemas and the meaning of their attributes
- **Implementation** (or **physical storage**) **level**
  - How the tuples in a base relation are stored and updated

Informal Design Guidelines for Relation Schemas

We will discuss four(04) *informal guidelines*

- Making sure that the semantics of the attributes is clear in the schema
- Reducing the redundant information in tuples
- Reducing the NULL values in tuples
- Disallowing the possibility of generating spurious tuples

Imparting Clear Semantics to Attributes in Relations

- The **semantics** of a relation refers to its meaning resulting from the interpretation of attribute values in a tuple
- The easier it is to explain the semantics of the relation, the better the relation schema design will be
- The ease with which the meaning of a relation's attributes can be explained is an *informal measure* of how well the relation is designed

Imparting Clear Semantics to Attributes in Relations

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

DEPT_LOCATIONS

Dnumber	Dlocation

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Imparting Clear Semantics to Attributes in Relations

EMPLOYEE F.K.

Ename	Ssn	Bdate	Address	Dnumber

P.K.

DEPARTMENT F.K.

Dname	Dnumber	Dmgr_ssn

P.K.

DEPT_LOCATIONS

F.K.

Dnumber	Dlocation

P.K.

PROJECT F.K.

Pname	Pnumber	Plocation	Dnum

P.K.

WORKS_ON

F.K. F.K.

Ssn	Pnumber	Hours

P.K.

Imparting Clear Semantics to Attributes in Relations

EMPLOYEE

Ename	Ssn	Bdate	Address	Dnumber
Smith, John B.	123456789	1965-01-09	731 Fondren, Houston, TX	5
Wong, Franklin T.	333445555	1955-12-08	638 Voss, Houston, TX	5
Zelaya, Alicia J.	999887777	1968-07-19	3321 Castle, Spring, TX	4
Wallace, Jennifer S.	987654321	1941-06-20	291Berry, Bellaire, TX	4
Narayan, Ramesh K.	666884444	1962-09-15	975 Fire Oak, Humble, TX	5
English, Joyce A.	453453453	1972-07-31	5631 Rice, Houston, TX	5
Jabbar, Ahmad V.	987987987	1969-03-29	980 Dallas, Houston, TX	4
Borg, James E.	888665555	1937-11-10	450 Stone, Houston, TX	1

DEPARTMENT

Dname	Dnumber	Dmgr_ssn
Research	5	333445555
Administration	4	987654321
Headquarters	1	888665555

DEPT_LOCATIONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

WORKS_ON

Ssn	Pnumber	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0
999887777	30	30.0
999887777	10	10.0
987987987	10	35.0
987987987	30	5.0
987654321	30	20.0
987654321	20	15.0
888665555	20	Null

PROJECT

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

Guideline 1

Informally, each tuple in a relation should represent one entity or relationship instance.

(Applies to individual relations and their attributes).

- Attributes of different entities (EMPLOYEEs, DEPARTMENTs, PROJECTs) should not be mixed in the same relation
- Only foreign keys should be used to refer to other entities
- Entity and relationship attributes should be kept apart as much as possible.

- Bottom Line: Design a schema that can be explained easily relation by relation. The semantics of attributes should be easy to interpret.

Examples of Violating Guideline 1

EMP_DEPT

Ename	Ssn	Bdate	Address	Dnumber	Dname	Dmgr_ssn

EMP_PROJ

Ssn	Pnumber	Hours	Ename	Pname	Plocation

Redundant Information in Tuples and Update Anomalies

- Mixing attributes of multiple entities may cause problems
- Information is stored redundantly wasting storage
- Causes problems with update anomalies
  - Insertion anomalies
  - Deletion anomalies
  - Modification anomalies

Redundant Information in Tuples and Update Anomalies

Redundancy

EMP_DEPT

Ename	Ssn	Bdate	Address	Dnumber	Dname	Dmgr_ssn
~~Smith, John B.~~	123456789	1965-01-09	731 Fondren, Houston, TX	5	Research	333445555
Wong, Franklin T.	333445555	1955-12-08	638 Voss, Houston, TX	5	Research	333445555
Zelaya, Alicia J.	999887777	1968-07-19	3321 Castle, Spring, TX	4	Administration	987654321
Wallace, Jennifer S.	987654321	1941-06-20	291 Berry, Bellaire, TX	4	Administration	987654321
Narayan, Ramesh K.	666884444	1962-09-15	975 FireOak, Humble, TX	5	Research	333445555
English, Joyce A.	453453453	1972-07-31	5631 Rice, Houston, TX	5	Research	333445555
Jabbar, Ahmad V.	987987987	1969-03-29	980 Dallas, Houston, TX	4	Administration	987654321
Borg, James E.	888665555	1937-11-10	450 Stone, Houston, TX	1	Headquarters	888665555

Redundancy

Redundancy

EMP_PROJ

Ssn	Pnumber	Hours	Ename	Pname	Plocation
123456789	1	32.5	Smith, John B.	ProductX	Bellaire
123456789	2	7.5	Smith, John B.	ProductY	Sugarland
666884444	3	40.0	Narayan, Ramesh K.	ProductZ	Houston
453453453	1	20.0	English, Joyce A.	ProductX	Bellaire
453453453	2	20.0	English, Joyce A.	ProductY	Sugarland
333445555	2	10.0	Wong, Franklin T.	ProductY	Sugarland
333445555	3	10.0	Wong, Franklin T.	ProductZ	Houston
333445555	10	10.0	Wong, Franklin T.	Computerization	Stafford
333445555	20	10.0	Wong, Franklin T.	Reorganization	Houston
999887777	30	30.0	Zelaya, Alicia J.	Newbenefits	Stafford
999887777	10	10.0	Zelaya, Alicia J.	Computerization	Stafford
987987987	10	35.0	Jabbar, Ahmad V.	Computerization	Stafford
987987987	30	5.0	Jabbar, Ahmad V.	Newbenefits	Stafford
987654321	30	20.0	Wallace, Jennifer S.	Newbenefits	Stafford
987654321	20	15.0	Wallace, Jennifer S.	Reorganization	Houston
888665555	20	Null	Borg, James E.	Reorganization	Houston

Update Anomalies

EMP_DEPT

Ename	Ssn	Bdate	Address	Dnumber	Dname	Dmgr_ssn

- **Insertion Anomalies**
  - Insertion anomalies can be differentiated into two types
  - Examples:
    - **To insert a new employee tuple into EMP_DEPT**
    - **To insert a new department into EMP_DEPT**

Update Anomalies

EMP_DEPT

Ename	Ssn	Bdate	Address	Dnumber	Dname	Dmgr_ssn

- **Deletion Anomalies**
  - The problem of deletion anomalies is related to the second insertion anomaly situation
    - **Delete an employee tuple(last or only) from EMP_DEPT**

Update Anomalies

EMP_DEPT

Ename	<u>Ssn</u>	Bdate	Address	Dnumber	Dname	Dmgr_ssn

- **Modification Anomalies**
  - **Changing the value of one of the attributes of a particular department**

Guideline 2

Design a schema that does not suffer from the insertion, deletion and update anomalies.

- If there are any anomalies present, then note them so that applications can be made to take them into account.

NULL Values in Tuples

- In some schema designs we may group many attributes together into a "fat" relation
- If many of the attributes do not apply to all tuples in the relation, we end up with many NULLs in those tuples
- NULLs can have multiple interpretations which can compromise the real meaning
  - The attribute *does not apply* to the tuple
  - The attribute value for this tuple is *unknown*
  - The value is *known but absent*

Guideline 3

Relations should be designed such that their tuples will have as few NULL values as possible

- Attributes that are NULL frequently could be placed in separate relations (with the primary key)

Generation of Spurious Tuples

EMP_PROJ

Ssn	Pnumber	Hours	Ename	Pname	Plocation

EMP_LOCS

Ename	Plocation

P.K.

EMP_PROJ1

Ssn	Pnumber	Hours	Pname	Plocation

P.K.

Generation of Spurious Tuples

EMP_LOCS

Ename	Plocation
Smith, John B.	Bellaire
Smith, John B.	Sugarland
Narayan, Ramesh K.	Houston
English, Joyce A.	Bellaire
English, Joyce A.	Sugarland
Wong, Franklin T.	Sugarland
Wong, Franklin T.	Houston
Wong, Franklin T.	Stafford

EMP_PROJ1

Ssn	Pnumber	Hours	Pname	Plocation
123456789	1	32.5	ProductX	Bellaire
123456789	2	7.5	ProductY	Sugarland
666884444	3	40.0	ProductZ	Houston
453453453	1	20.0	ProductX	Bellaire
453453453	2	20.0	ProductY	Sugarland
333445555	2	10.0	ProductY	Sugarland
333445555	3	10.0	ProductZ	Houston
333445555	10	10.0	Computerization	Stafford
333445555	20	10.0	Reorganization	Houston

Generation of Spurious Tuples

	Ssn	Pnumber	Hours	Pname	Plocation	Ename
	123456789	1	32.5	ProductX	Bellaire	Smith, John B.
*	123456789	1	32.5	ProductX	Bellaire	English, Joyce A.
	123456789	2	7.5	ProductY	Sugarland	Smith, John B.
*	123456789	2	7.5	ProductY	Sugarland	English, Joyce A.
*	123456789	2	7.5	ProductY	Sugarland	Wong, Franklin T.
	666884444	3	40.0	ProductZ	Houston	Narayan, Ramesh K.
*	666884444	3	40.0	ProductZ	Houston	Wong, Franklin T.
*	453453453	1	20.0	ProductX	Bellaire	Smith, John B.
	453453453	1	20.0	ProductX	Bellaire	English, Joyce A.
*	453453453	2	20.0	ProductY	Sugarland	Smith, John B.
	453453453	2	20.0	ProductY	Sugarland	English, Joyce A.
*	453453453	2	20.0	ProductY	Sugarland	Wong, Franklin T.
*	333445555	2	10.0	ProductY	Sugarland	Smith, John B.
*	333445555	2	10.0	ProductY	Sugarland	English, Joyce A.
	333445555	2	10.0	ProductY	Sugarland	Wong, Franklin T.
*	333445555	3	10.0	ProductZ	Houston	Narayan, Ramesh K.
	333445555	3	10.0	ProductZ	Houston	Wong, Franklin T.
	333445555	10	10.0	Computerization	Stafford	Wong, Franklin T.
*	333445555	20	10.0	Reorganization	Houston	Narayan, Ramesh K.
	333445555	20	10.0	Reorganization	Houston	Wong, Franklin T.

*
*

Generation of Spurious Tuples

- Bad designs for a relational database may result in erroneous results for certain JOIN operations
- The "lossless join" property is used to guarantee meaningful results for join operations
- Additional tuples that were not in EMP_PROJ are called **spurious tuples** because they represent spurious information that is not valid. (The spurious tuples are marked by asterisks (*) in the above example)

Guideline 4

- The relations should be designed to satisfy the lossless join condition.
- No spurious tuples should be generated by doing a natural-join of any relations.

Summary of Design Guidelines

- we informally discussed situations that lead to problematic relation schemas, and we proposed informal guidelines for a good relational design
- The problems we pointed out, which can be detected without additional tools of analysis, are as follows
  - Anomalies that cause redundant work to be done during insertion into and modification of a relation, and that may cause accidental loss of information during a deletion from a relation
  - Waste of storage space due to NULLs and the difficulty of performing selections, aggregation operations, and joins due to NULL values
  - Generation of invalid and spurious data during joins on base relations with matched attributes that may not represent a proper (foreign key, primary key) relationship

Functional Dependencies

- A functional dependency is a constraint between two sets of attributes from the database
- 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

  $$R = \{A1, A2, \ldots, An\}$$

- Note :
  - We do not imply that we will actually store the database as a single universal table
  - We use this concept only in developing the formal theory of data dependencies

Functional Dependencies Definition

- A functional dependency, denoted by

  $X \rightarrow Y$,

  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

- 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.

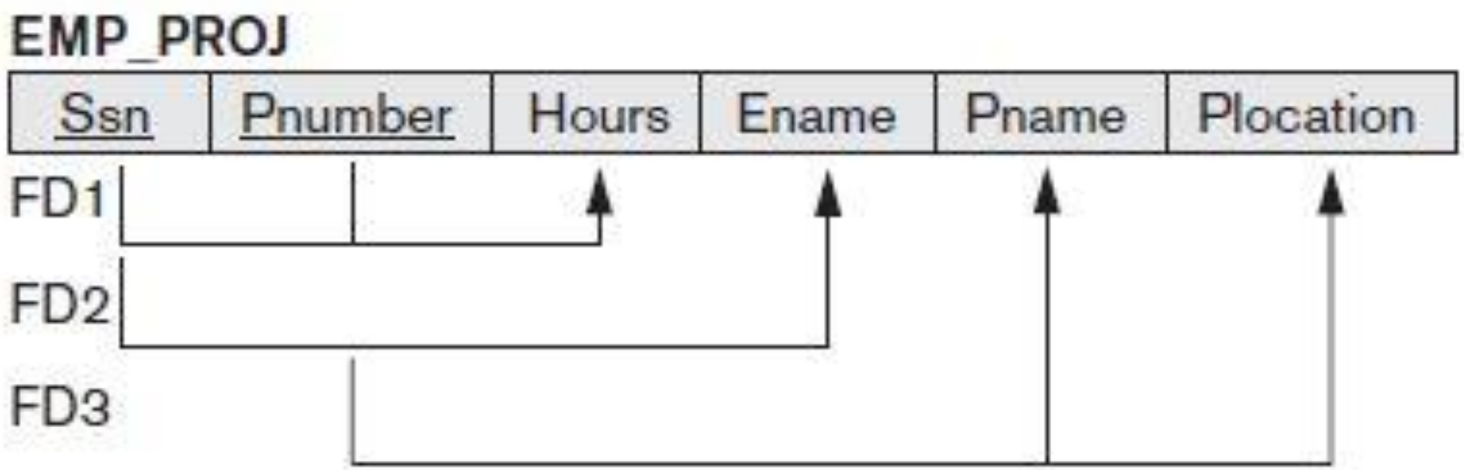
Functional Dependencies

- X functionally determines Y in a relation schema R if, and only if, whenever two tuples of r(R) agree on their X-value, they must necessarily agree on their Yvalue.
  - 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 $X \rightarrow Y$ 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 $X \rightarrow R$.
  - If $X \rightarrow Y$ in R, this does not say whether or not $Y \rightarrow X$ in R.

Functional Dependencies

- A functional dependency is a property of the semantics or meaning of the attributes.
- Relation extensions r(R) that satisfy the functional dependency constraints are called legal relation states (or legal extensions) of R.

Functional Dependencies



Functional Dependencies in EMP_PROJ

Ssn→Ename

Pnumber →{Pname, Plocation}

{Ssn, Pnumber}→Hours

Functional Dependencies

TEACH

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

Functional Dependencies

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

Inference Rules for FDs (1)

- Given a set of FDs F, we can **infer** additional FDs that hold whenever the FDs in F hold
- Armstrong's inference rules:
  - IR1. (**Reflexive**) If Y *subset-of* X, then X -> Y
  - IR2. (**Augmentation**) If X -> Y, then XZ -> YZ
    - (Notation: XZ stands for X U Z)
  - IR3. (**Transitive**) If X -> Y and Y -> Z, then X -> Z

- IR1, IR2, IR3 form a **sound** and **complete** set of inference rules
  - These are rules hold and all other rules that hold can be deduced from these

Inference Rules for FDs (2)

- Some additional inference rules that are useful:
  - **Decomposition:** If X -> YZ,
    then X -> Y and X -> Z
  - **Union:** If X -> Y and X -> Z,
    then X -> YZ
  - **Psuedo transitivity:** If X -> Y and WY -> Z,
    then WX -> Z

- The last three inference rules, as well as any other inference rules, can be deduced from IR1, IR2, and IR3 (completeness property)

Normalization of Relations (1)

- **Normalization:**
  - The process of decomposing unsatisfactory "bad" relations by breaking up their attributes into smaller relations

- **Normal form:**
  - Condition using keys and FDs of a relation to certify whether a relation schema is in a particular normal form

Normalization of Relations (2)

- 2NF, 3NF, BCNF
  - based on keys and FDs of a relation schema
- 4NF
  - based on keys, multi-valued dependencies : MVDs;
- 5NF
  - based on keys, join dependencies : JDs
- Additional properties may be needed to ensure a good relational design (lossless join, dependency preservation;)

Practical Use of Normal Forms

- **Normalization** is carried out in practice so that the resulting designs are of high quality and meet the desirable properties
- The practical utility of these normal forms becomes questionable when the constraints on which they are based are *hard to understand* or to *detect*
- The database designers *need not* normalize to the highest possible normal form
  - usually up to 3NF, BCNF
    (4NF etc rarely used in practice)

- **Denormalization**:
  - The process of storing the join of higher normal form relations as a base relation—which is in a lower normal form

Definitions of Keys and Attributes Participating in Keys (1)

- A **superkey** of a relation schema

  R = {A1, A2, ..., An}

  is a set of attributes S *subset-of* R with the property that no two tuples t1 and t2 in any legal relation state r of R will have

  t1[S] = t2[S]

- A **key** K is a **superkey** with the *additional property* that removal of any attribute from K will cause K not to be a superkey anymore.

Definitions of Keys and Attributes Participating in Keys (2)

- If a relation schema has more than one key, each is called a **candidate** key.
  - One of the candidate keys is *arbitrarily* designated to be the **primary key**, and the others are called **secondary keys**.
- A **Prime attribute** must be a member of *some* candidate key
- A **Nonprime attribute** is not a prime attribute—that is, it is not a member of any candidate key.

First Normal Form

- Disallows
  - composite attributes
  - multivalued attributes
  - nested relations
    - attributes whose values for an *individual tuple* are non-atomic

- Considered to be part of the definition of relation

Normalization into 1NF

(a)

DEPARTMENT

Dname	Dnumber	Dmgr_ssn	Dlocations

(b)

DEPARTMENT

Dname	Dnumber	Dmgr_ssn	Dlocations
Research	5	333445555	{Bellaire, Sugarland, Houston}
Administration	4	987654321	{Stafford}
Headquarters	1	888665555	{Houston}

(c)

DEPARTMENT

Dname	Dnumber	Dmgr_ssn	Dlocation
Research	5	333445555	Bellaire
Research	5	333445555	Sugarland
Research	5	333445555	Houston
Administration	4	987654321	Stafford
Headquarters	1	888665555	Houston

Normalization into 1NF. (a) A relation schema that is not in 1NF. (b) Example state of relation DEPARTMENT. (c) 1NF version of the same relation with redundancy.

Normalization nested relations into 1NF

(a)

EMP_PROJ

Ssn	Ename	Projs	
		Pnumber	Hours

(b)

EMP_PROJ

Ssn	Ename	Pnumber	Hours
123456789	Smith, John B.	1	32.5
		2	7.5
666884444	Narayan, Ramesh K.	3	40.0
453453453	English, Joyce A.	1	20.0
		2	20.0
333445555	Wong, Franklin T.	2	10.0
		3	10.0
		10	10.0
		20	10.0
999887777	Zelaya, AliciaJ.	30	30.0
		10	10.0
987987987	Jabbar, Ahmad V.	10	35.0
		30	5.0
987654321	Wallace, Jennifer S.	30	20.0
		20	15.0
888665555	Borg, James E.	20	NULL

(c)

EMP_PROJ1

Ssn	Ename

EMP_PROJ2

Ssn	Pnumber	Hours

Normalizing nested relations into 1NF. (a) Schema of the EMP_PROJ relation with a *nested relation* attribute PROJS. (b) Example extension of the EMP_PROJ relation showing nested relations within each tuple. (c) Decomposition of EMP_PROJ into relations EMP_PROJ1 and EMP_PROJ2 by propagating the primary key.

Second Normal Form (1)

- Uses the concepts of **FDs, primary key**
- Definitions
  - **Prime attribute:** An attribute that is member of the primary key K
  - **Full functional dependency:** a FD Y -> Z where removal of any attribute from Y means the FD does not hold any more
- Examples:
  - {SSN, PNUMBER} -> HOURS

  is a full FD since neither

  SSN -> HOURS nor PNUMBER -> HOURS hold
  - {SSN, PNUMBER} -> ENAME

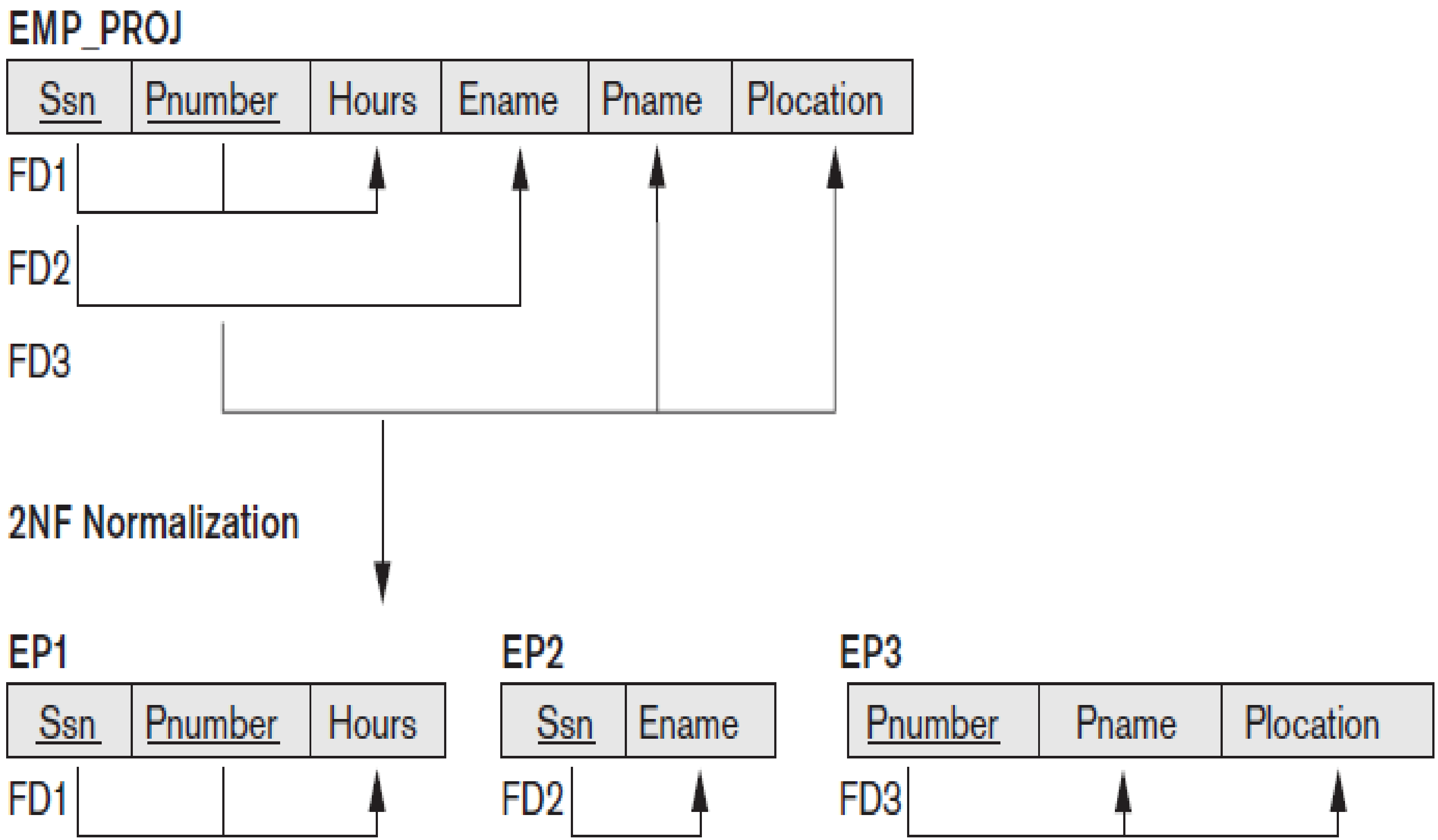
  is not a full FD (it is called a partial dependency)

  since SSN -> ENAME also holds

Second Normal Form (2)

- A relation schema R is in **second normal form (2NF)** if every non-prime attribute A in R is fully functionally dependent on the primary key
- R can be decomposed into 2NF relations via the process of 2NF normalization

Normalizing into 2NF



Third Normal Form (1)

- Definition:
  - **Transitive functional dependency:**

    a FD X -> Z that can be derived from two FDs

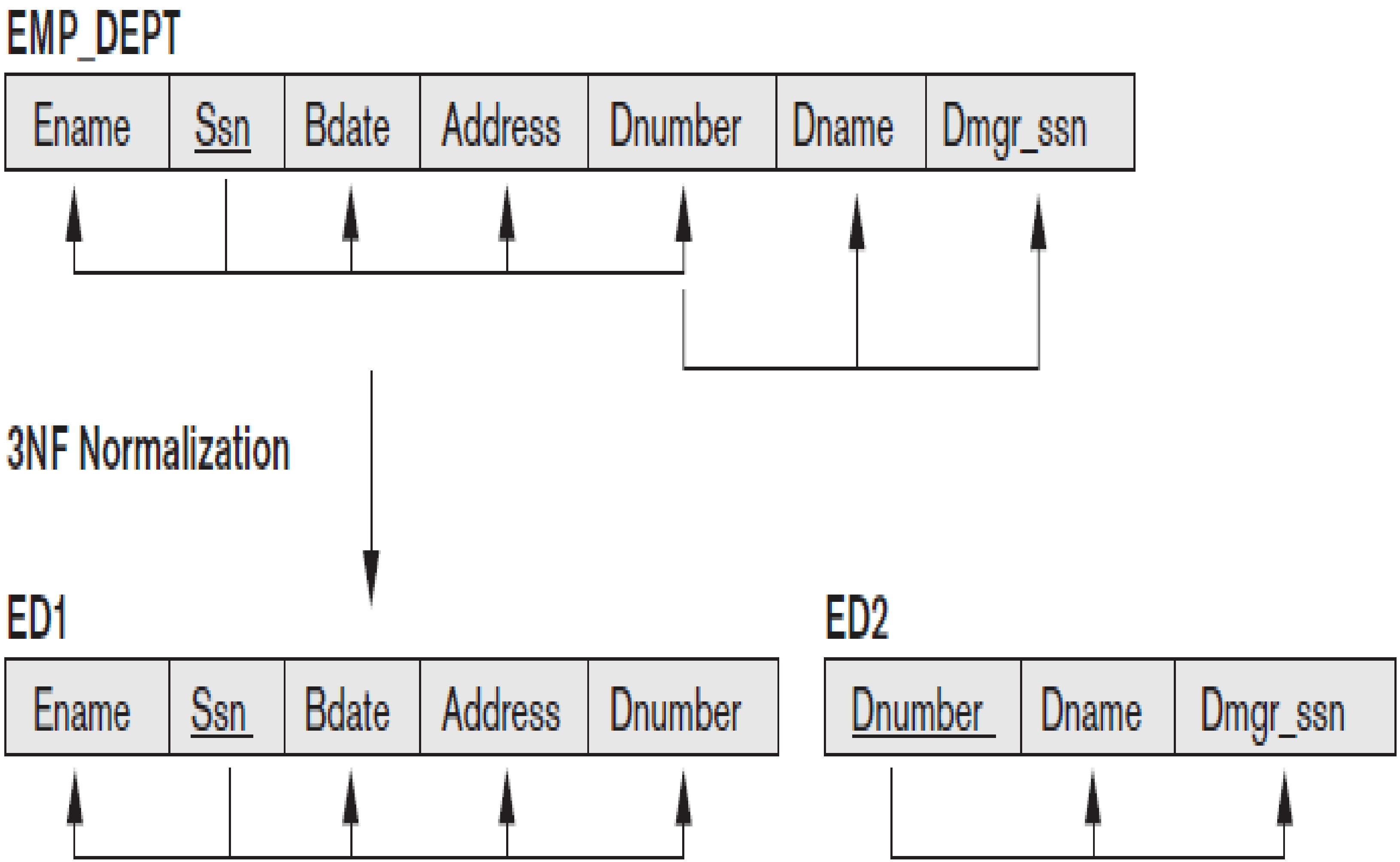
    X -> Y and Y -> Z
- Examples:
  - SSN -> DMGRSSN is a **transitive** FD
    - Since SSN -> DNUMBER and DNUMBER -> DMGRSSN hold
  - SSN -> ENAME is **non-transitive**
    - Since there is no set of attributes X where

      SSN -> X and X -> ENAME

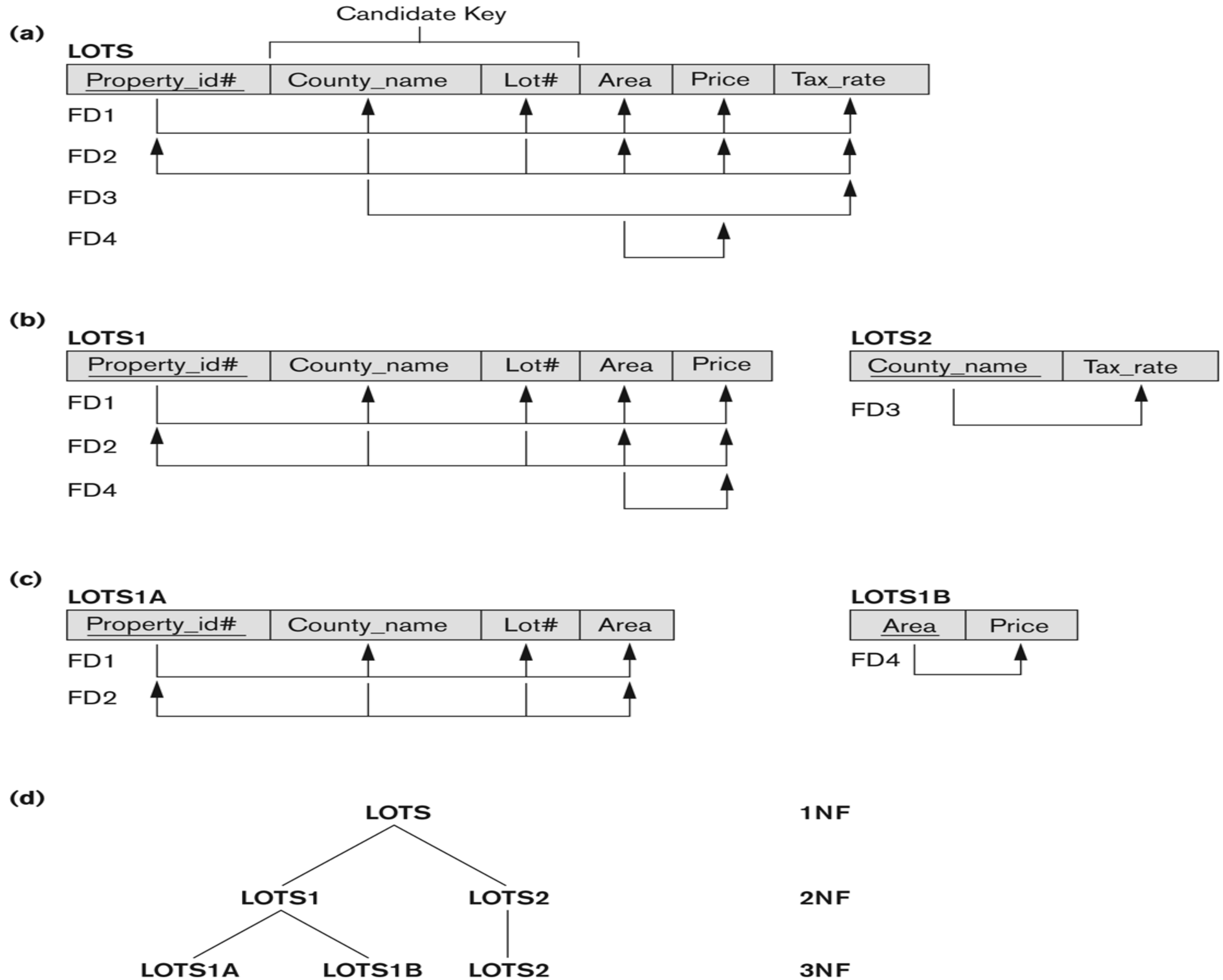
Third Normal Form (2)

- A relation schema R is in **third normal form (3NF)** if it is in 2NF *and* no non-prime attribute A in R is transitively dependent on the primary key
- R can be decomposed into 3NF relations via the process of 3NF normalization
- NOTE:
  - In X -> Y and Y -> Z, with X as the primary key, we consider this a problem only if Y is not a candidate key.
  - When Y is a candidate key, there is no problem with the transitive dependency .
  - E.g., Consider EMP (SSN, Emp#, Salary).
    - Here, SSN -> Emp# -> Salary and Emp# is a candidate key.

Normalizing into 3NF



Normalization into 2NF and 3NF



Normalization into 2NF and 3NF. (a) The LOTS relation with its functional dependencies FD1 through FD4. (b) Decomposing into the 2NF relations LOTS1 and LOTS2. (c) Decomposing LOTS1 into the 3NF relations LOTS1A and LOTS1B. (d) Summary of the progressive normalization of LOTS.

Normal Forms Defined Informally

- 1^{st} normal form
  - All attributes depend on **the key**
- 2^{nd} normal form
  - All attributes depend on **the whole key**
- 3^{rd} normal form
  - All attributes depend on **nothing but the key**

General Normal Form Definitions (For Multiple Keys) (1)

- The above definitions consider the primary key only
- The following more general definitions take into account relations with multiple candidate keys
  - Any attribute involved in a candidate key is a prime attribute
  - All other attributes are called non-prime attributes.

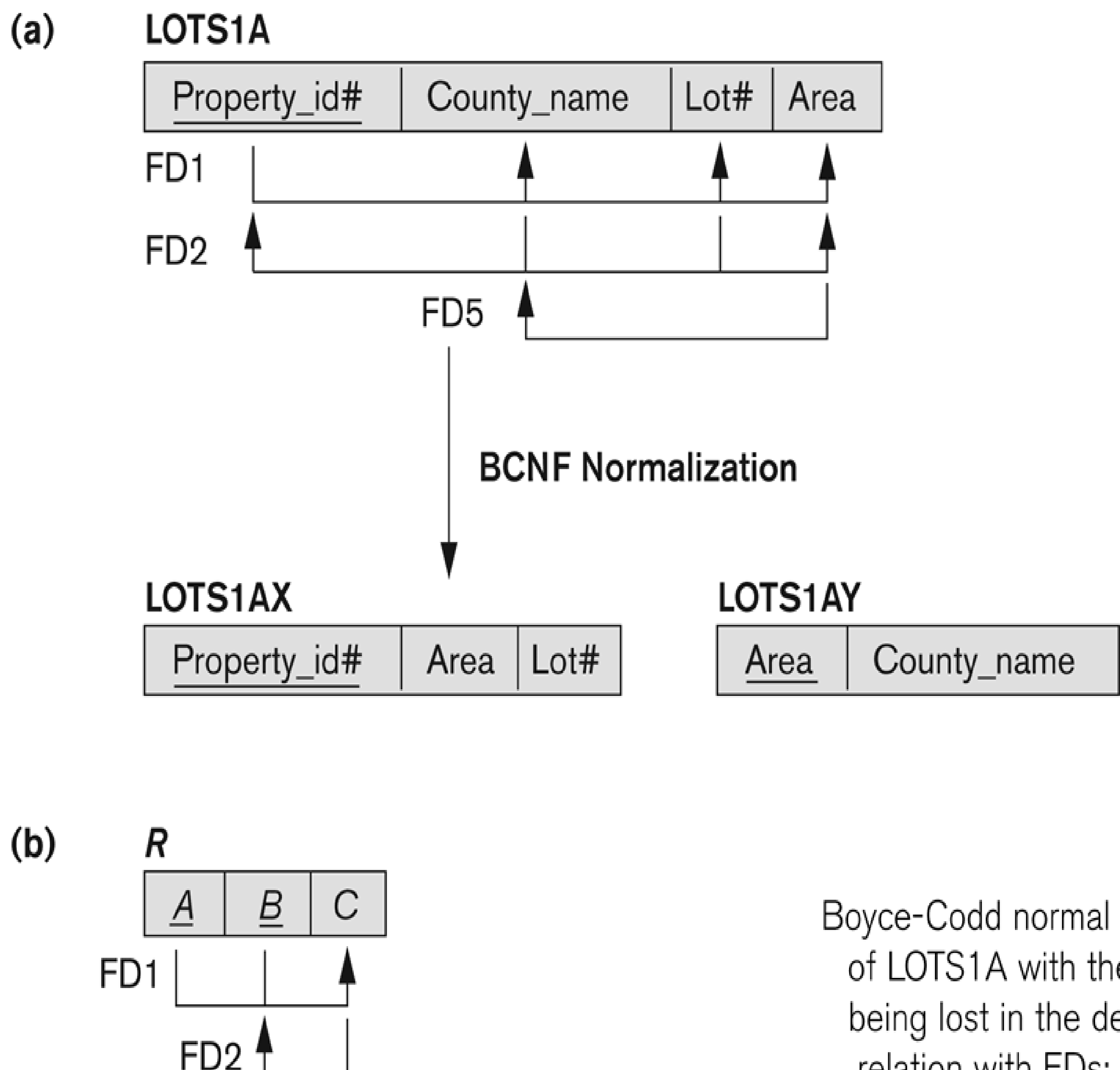
General Normal Form Definitions (2)

- Definition:
  - **Superkey** of relation schema R - a set of attributes S of R that contains a key of R
  - A relation schema R is in **third normal form (3NF)** if whenever a FD X -> A holds in R, then either:
    - (a) X is a superkey of R, or
    - (b) A is a prime attribute of R
- NOTE: Boyce-Codd normal form disallows condition (b) above

BCNF (Boyce-Codd Normal Form)

- A relation schema R is in **Boyce-Codd Normal Form (BCNF)** if whenever an **FD X -> A** holds in R, then **X is a superkey** of R
- Each normal form is strictly stronger than the previous one
  - Every 2NF relation is in 1NF
  - Every 3NF relation is in 2NF
  - Every BCNF relation is in 3NF
- There exist relations that are in 3NF but not in BCNF
- Hence BCNF is considered a stronger form of 3NF
- The goal is to have each relation in BCNF (or 3NF)

Boyce-Codd normal form



Boyce-Codd normal form. (a) BCNF normalization of LOTS1A with the functional dependency FD2 being lost in the decomposition. (b) A schematic relation with FDs; it is in 3NF, but not in BCNF.

A relation TEACH that is in 3NF but not in BCNF

TEACH

Student	Course	Instructor
Narayan	Database	Mark
Smith	Database	Navathe
Smith	Operating Systems	Ammar
Smith	Theory	Schulman
Wallace	Database	Mark
Wallace	Operating Systems	Ahamad
Wong	Database	Omiecinski
Zelaya	Database	Navathe
Narayan	Operating Systems	Ammar

A relation TEACH that is in 3NF but not BCNF.

Achieving the BCNF by Decomposition(1)

- Two FDs exist in the relation TEACH:
  - fd1: { student, course} -> instructor
  - fd2: instructor -> course
- {student, course} is a candidate key for this relation and that the dependencies shown follow the pattern in Figure 10.12 (b).
  - So this relation is in 3NF *but not in* BCNF
- A relation **NOT** in BCNF should be decomposed so as to meet this property, while possibly forgoing the preservation of all functional dependencies in the decomposed relations.
  - (See Algorithm 11.3)

Achieving the BCNF by Decomposition(2)

- Three possible decompositions for relation TEACH
  - {<u>student, instructor</u>} and {<u>student, course</u>}
  - {course, <u>instructor</u> } and {<u>course, student</u>}
  - {<u>instructor</u>, course } and {<u>instructor, student</u>}
- All three decompositions will lose fd1.
  - We have to settle for sacrificing the functional dependency preservation. But we cannot sacrifice the non-additivity property after decomposition.
- Out of the above three, only the 3rd decomposition will not generate spurious tuples after join.(and hence has the non-additivity property).
- A test to determine whether a binary decomposition (decomposition into two relations) is non-additive (lossless) is discussed in section 11.1.4 under Property LJ1. Verify that the third decomposition above meets the property.

Questions ???

Thank You

References

- *Chapter 15 : Fundamentals of Database Systems*

(6th Edition) By Remez Elmasri & Shamkant B. Navathe