

Normalization -- Practice

EGCI 321: LECTURE 13 (WEEK 9)

Redundancy

Redundancy is at the root of several problems associated with relational schemas:

- Redundant storage, insert/delete/update anomalies
- Integrity constraints, in particular *functional dependencies*, can be used to identify schemas with such problems and to suggest refinements
- Main refinement technique: *decomposition* (replacing ABCD with, say, AB and BCD, or ACD and ABD)

Data redundancy and update anomalies

Tables that contain redundant information may potentially **suffer from update anomalies.**

Types of update anomalies include

- Insertion
- Deletion
- Modification

Data redundancy and update anomalies

staffNo	name	position	salary	branchNo	branchAddress	telNo
S1500	Tom Daniels	Manager	46000	B001	8 Jefferson Way, Portland, OR 97201	503-555-3618
S0003	Sally Adams	Assistant	30000	B001	8 Jefferson Way, Portland, OR 97201	503-555-3618
S0010	Mary Martinez	Manager	50000	B002	City Center Plaza, Seattle, WA 98122	206-555-6756
S3250	Robert Chin	Supervisor	32000	B002	City Center Plaza, Seattle, WA 98122	206-555-6756
S2250	Sally Stern	Manager	48000	B004	16 – 14th Avenue, Seattle, WA 98128	206-555-3131
S0415	Art Peters	Manager	41000	B003	14 – 8th Avenue, New York, NY 10012	212-371-3000

Data redundancy and update anomalies (cont.)

Staff

staffNo	name	position	salary	branchNo
S1500	Tom Daniels	Manager	46000	B001
S0003	Sally Adams	Assistant	30000	B001
S0010	Mary Martinez	Manager	50000	B002
S3250	Robert Chin	Supervisor	32000	B002
S2250	Sally Stern	Manager	48000	B004
S0415	Art Peters	Manager	41000	B003

Branch

branchNo	branchAddress	telNo
B001	8 Jefferson Way, Portland, OR 97201	503-555-3618
B002	City Center Plaza, Seattle, WA 98122	206-555-6756
B003	14 – 8th Avenue, New York, NY 10012	212-371-3000
B004	16 – 14th Avenue, Seattle, WA 98128	206-555-3131

Functional Dependencies

Definition

- $x \rightarrow y$
- x functionally determines y in a relation R
- OR y is functionally dependent on x
- If each x -value in the relation is associated with only one y -value at any one time
- x and y may be composite attributes
- y may be associated with more than one x

Functional Dependencies

- Functional Dependency (FD)

- Tool for analyzing relation schemas
- A constraint among attributes in a relation based on the semantics of attributes
- Identify by the database designer from a relation schema (not a relation state)
- Use to determine what normal form a relation schema is in

Functional Dependencies

■ Example1 (2NF)

- EMP_PROJ (SSN, PNO, HOURS, ENAME, PNAME, PLOCATION)
- SSN → ENAME, PNO
- PNO → PNAME, PLOCATION
- {SSN, PNO} → HOURS

■ Example2

- STUDENT_COURSE Relation
(SSN, COURSEID, SECTIONID, YEAR SNAME, SADDRESS, STATUS, CNAME, CDESC, GRADE)
- Functional Dependencies:
 $SSN \rightarrow SNAME, SADDRESS, STATUS$
 $\{COURSEID, YEAR\} \rightarrow CNAME, CDESC$
 $\{SSN, COURSEID, SECTIONID, YEAR\} \rightarrow GRADE$

Functional Dependencies

Transitive Functional Dependency

- y is transitively functionally dependent on x if x functionally determines z (not a candidate key or a subset) and z functionally determines y
- $x \rightarrow y$ if $x \rightarrow z$ and $z \rightarrow y$
- e.g. SSN \rightarrow PNO and PNO \rightarrow PLOCATION, then SSN \rightarrow PLOCATION (SSN transitively determines PLOCATION)

Multi-Valued (Is it 1NF?)

Staff

<u>ENO</u>	Name	Dno	DeptName	ProjNo	ProjName
E001	Somchai	D01	Physic	P01, P02	NMR, Laser
E002	Sompong	D01	Physic	P03	Medical Image processing
E003	Somchay	D02	Computer Science	P04, P05	Voice ordering, Speech Coding
E004	SomSiri	D02	Computer Science	P04, P06	Voice ordering, Speech Synthesis

Multi-Valued (cont.)

<u>ENO</u>	Name	Dno	DeptName	<u>ProjNo</u>	ProjName
E001	Somchai	D01	Physic	P01	NMR
E001	Somchai	D01	Physic	P02	Laser
E002	Sompong	D01	Physic	P03	Medical Image processing
E003	Somchay	D02	Computer Science	P05	Voice ordering
E003	Somchay	D02	Computer Science	P04	Speech Coding
E004	SomSiri	D02	Computer Science	P04	Speech Coding
E004	SomSiri	D02	Computer Science	P06	Speech Synthesis

Insert a new project but there is still has problem

Second Normal Form (2NF)

A relation is in first normal form if and only if

- It is in 1NF
- Every **non-key** attribute is dependent on **all parts of the primary key**.

2NF ?

Staff

<u>ENO</u>	Name	Dno	DeptName	ProjNo	ProjName
E001	Somchai	D01	Physic	P01	NMR
E001	Somchai	D01	Physic	P02	Laser
E002	Sompong	D01	Physic	P03	Medical Image processing
E003	Somchay	D02	Computer Science	P05	Voice ordering
E003	Somchay	D02	Computer Science	P04	Speech Coding
E004	SomSiri	D02	Computer Science	P04	Speech Coding
E004	SomSiri	D02	Computer Science	P06	Speech Synthesis

KEY = ENO + ProjNo

Answer is No. Because
ProjName is dependent on
ProjNo. (not all part of Key)

Problem

<u>ENO</u>	Name	Dno	DeptName	<u>ProjNo</u>	<u>ProjName</u>
E001	Somchai	D01	Physic	P01	NMR
E001	Somchai	D01	Physic	P02	Laser
E002	Sompong	D01	Physic	P03	Medical Image processing
E003	Somchay	D02	Computer Science	P05	Voice ordering
E003	Somchay	D02	Computer Science	P04	Speech Coding
E004	SomSiri	D02	Computer Science	P04	Speech Coding
E004	SomSiri	D02	Computer Science	P06	Speech Synthesis

We can not insert Project if they have not yet assigned project to any employee



Solution

Remove the attribute involved

Take its determinant with it

Normalize

<u>ENO</u>	Name	Dno	DeptName	<u>ProjNo</u>	ProjName
E001	Somchai	D01	Physic	P01	NMR
E001	Somchai	D01	Physic	P02	Laser
E002	Sompong	D01	Physic	P03	Medical Image processing
E003	Somchay	D02	Computer Science	P05	Voice ordering
E003	Somchay	D02	Computer Science	P04	Speech Coding
E004	SomSiri	D02	Computer Science	P04	Voice ordering
E004	SomSiri	D02	Computer Science	P06	Speech Synthesis

Result: 2NF

PERSON

<u>ENO</u>	Name	Dno	DeptName
E001	Somchai	D01	Physic
E003	Somchay	D02	Computer Science
E004	SomSiri	D02	Computer Science

PROJECT

<u>ProjNo</u>	ProjName
P01	NMR
P02	Laser
P03	Medical Image processing
P04	Speech Coding
P05	Voice ordering
P06	Speech Synthesis

PERSON_PROJECT

<u>ENO</u>	<u>ProjNo</u>
E001	P01
E001	P02
E002	P03
E003	P04
E003	P05
E004	P04
E004	P06

PERSON(ENO,NAME,Dno,DeptName)

PROJECT(ProjNo,ProjName)

PERSON_PROJ(ENO,ProjNo)

Third Normal Form

A relation is in 3NF if, and only if:

- It is in 2NF
- Every non-key attribute is functionally dependent upon the key (**No non-key attribute is functional dependent on another non-key attribute**)
- Or non-key attribute no **transitive dependent** on key

Transitive dependent

- $R(\underline{A},B,C,D)$; A is Key, others are non- key
- If $A \rightarrow B$ and $B \rightarrow C$ can say
 $A \rightarrow B \rightarrow C$ (C transitive dependent on A)

3NF?

PERSON

<u>ENO</u>	Name	Dno	DeptName
E001	Somchai	D01	Physic
E003	Somchay	D02	Computer Science
E004	SomSiri	D02	Computer Science

PROJECT

<u>ProjNo</u>	ProjName
P01	NMR
P02	Laser
P03	Medical Image processing
P04	Speech Coding
P05	Voice ordering
P06	Speech Synthesis

PERSON_PROJECT

<u>ENO</u>	<u>ProjNo</u>
E001	P01
E001	P02
E002	P03
E003	P04
E003	P05
E004	P04
E004	P06

Answer is No

Because DeptName is dependent on Dno
(has transitive dependent on key)

Solution

- Remove the offending attributes
- Take the determinant along

Result

PERSON

<u>ENO</u>	Name	Dno
E001	Somchai	D01
E003	Somchay	D02
E004	SomSiri	D02

DEPARTMENT

<u>Dno</u>	DeptName
D01	Physic
D02	Computer Science

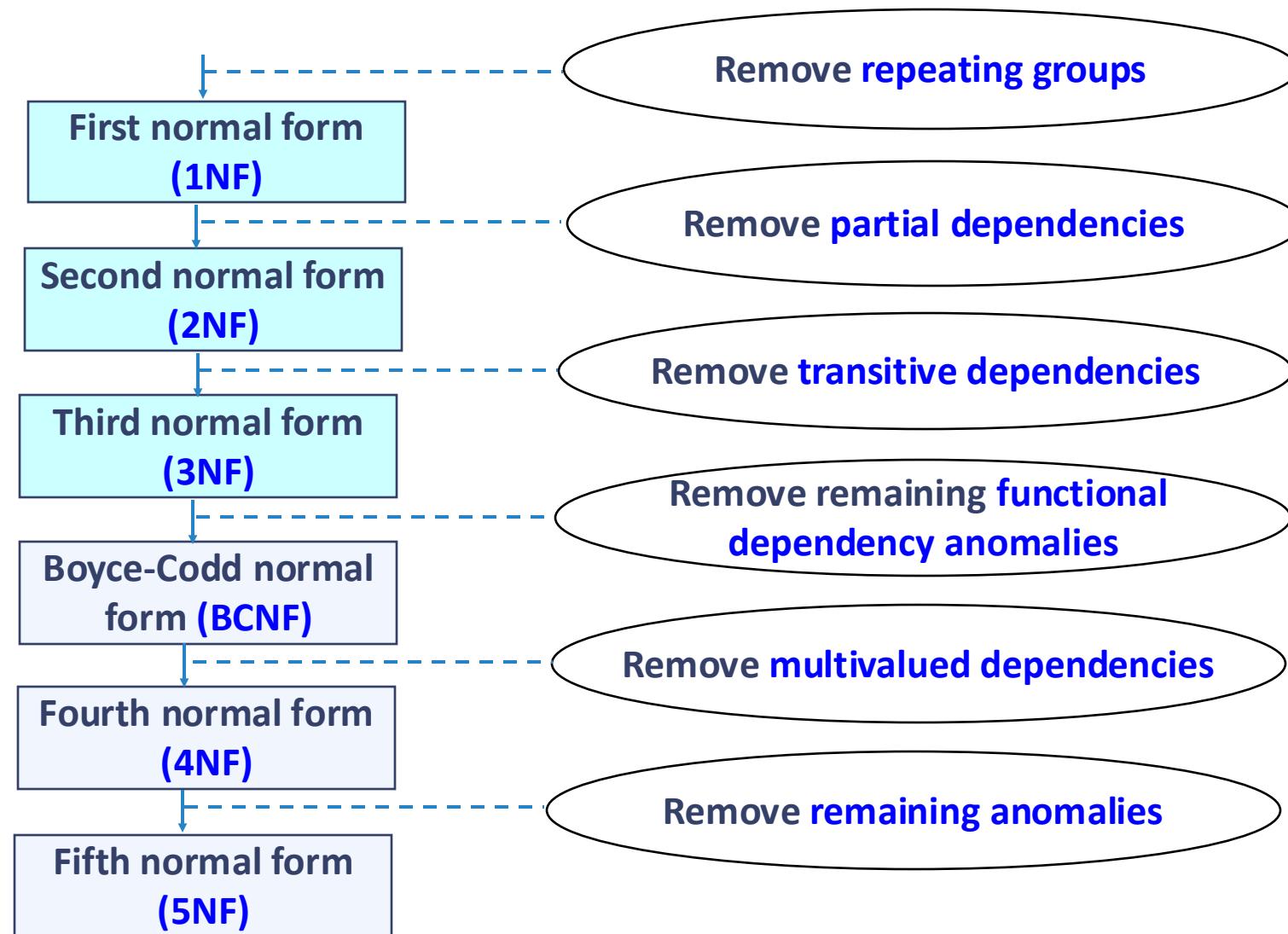
PROJECT

<u>ProjNo</u>	ProjName
P01	NMR
P02	Laser
P03	Medical Image processing
P04	Speech Coding
P05	Voice ordering
P06	Speech Synthesis

PERSON_Proj

<u>ENO</u>	<u>ProjNo</u>
E001	P01
E001	P02
E002	P03
E003	P04
E003	P05
E004	P04
E004	P06

Stages of Normalisation



BCNF (Boyce-Codd Normal Form)

A relation schema R is in **Boyce-Codd Normal Form (BCNF)** if whenever an FD $X \rightarrow A$ 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
- The goal is to have each relation in BCNF (or 3NF)

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	Omiedinski
Zelaya	Database	Navathe

BCNF

3NF Functional Dependencies

- $\{\text{Student}, \text{Course}\} \rightarrow \text{Instructor}$
- $\text{Instructor} \rightarrow \text{Course}$
- Decomposing into 2 schemas of BCNF (Which one is good?)
 - 1) $\{\text{Student}, \text{Instructor}\} \{\text{Student}, \text{Course}, \text{Instructor}\}$
 - 2) $\{\text{Instructor}, \text{Course}\} \{\text{Student}, \text{Course}, \text{Instructor}\}$
 - 3) $\{\text{Instructor}, \text{Course}\} \{\text{Instructor}, \text{Student}\}$

Reference

1. Ramakrishnan R, Gehrke J., Database management systems, 3rd ed., New York (NY): McGraw-Hill, 2003.