IT Department

Normalization and Normal Forms

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Database Systems I (IT 215)

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Outline

- **Normalization**
- **Normal Forms**
  - First Normal Form (**1NF**)
  - Second Normal Form (**2NF**)
  - Third Normal Form (**3NF**)

Normalization

- **Normalization** → is the process of efficiently organizing data in a database.
- Two main objectives of the normalization process:
  1. **Deleting redundant data** (storing the same data in more than one table)
  2. **Ensuring data dependencies make sense** (only storing related data in a table).

Is This Table Well-Structured? No! Too Much Duplicated Data!

Student ID	Student Name	DateOfBirth	deptName	deptBuilding	deptFloor
11	Mahmood	22.09.2001	IT	1	3
12	Karzan	11.06.1997	IT	1	3
13	Sarah	28.03.2004	IT	1	3
14	Tara	05.04.1995	IT	1	3
15	Ali	10.12.2002	IT	1	3
16	Kawa	17.07.2006	English	2	2
17	Lana	01.10.2003	English	2	2

Is This Table Well-Structured?
No! Duplicated Data and Multi-Valued Cells!

Student ID	Student Name	Email	Supervisor ID	Supervisor Rank	Supervisor Major
11	Mahmood	mh2001@gmail.com, Mahmood@yahoo.com	IT06	Lect.	Software Eng
12	Karzan	karzan@yahoo.com	EN11	Prof.	Literature
13	Sarah	sarah2000@gmail.com, Sara.ahmed@yahoo.com	IT02	Assist. Prof.	MIS
14	Tara	Tara.ihsan@gmail.com	IT06	Lect.	Software Eng
15	Ali	ali1999@gmail.com	BI20	Assist. Lect.	Biology

Normal Forms

- **Normal Forms** → Normalization uses a series of rules (called as **normal forms**) to help identify the optimal grouping of attributes in each table.
- There are three most-used normal forms:
  1. **First Normal Form (1NF)**
  2. **Second Normal Form (2NF)**
  3. **Third Normal Form (3NF)**

First Normal Form (1NF)

- A table is in **first normal form (1NF)**, if and only if:
  - Every attribute is **single-valued** for each row.

    (The domains of attributes of the relations are **atomic**)
  - There are **no repeating groups**(columns) in a row.

Is This Table in 1NF?

stuId	lastName	major	credits	status
S1001	Smith	History	90	Senior
S1003	Jones	Math	95	Senior
S1006	Lee	CSC, Math	15	Freshman
S1010	Burns	Art, English	63	Junior
S1060	Jones	CSC	25	Freshman

Is This Table in 1NF?

- First normal form (1NF) rule,
  - Every attribute must be single-valued for each row.
    - ✗ **major** is not single-valued, so the table is not in 1NF.

stuId	lastName	major	credits	status
S1001	Smith	History	90	Senior
S1003	Jones	Math	95	Senior
S1006	Lee	CSC, Math	15	Freshman
S1010	Burns	Art, English	63	Junior
S1060	Jones	CSC	25	Freshman

Solution → First Normal Form (1NF)

stuId	lastName	major	credits	status
S1001	Smith	History	90	Senior
S1003	Jones	Math	95	Senior
S1006	Lee	CSC	15	Freshman
S1006	Lee	Math	15	Freshman
S1010	Burns	Art	63	Junior
S1010	Burns	English	63	Junior
S1060	Jones	CSC	25	Freshman

Second Normal Form (2NF)

- A table is **Second Normal Form (2NF)**, if and only if:
  - It is the **first normal form (1NF)**
  - There is **NO partial dependency.** (All the **non-key attributes** are fully functionally dependent on the key.)
- In a table R, attribute A of R is **fully functionally dependent** on an attribute or set of attributes X of R if A is functionally dependent on X but not functionally dependent on any proper subset of X.

$$X \rightarrow A$$

Is This Table in 2NF?

NewClass

classNo	stuId	lastName	facId	schedule	room	grade
ART103A	S1001	Smith	F101	MWF9	H221	A
ART103A	S1010	Burns	F101	MWF9	H221	
ART103A	S1006	Lee	F101	MWF9	H221	B
CSC201A	S1003	Jones	F105	TuThF10	M110	A
CSC201A	S1006	Lee	F105	TuThF10	M110	C
HST205A	S1001	Smith	F202	MWF11	H221	

Is This Table in 2NF?

- Second normal form (2NF) rules,
  1. The table must be first normal form (1NF),
     ✓ all attributes (fields) are single-valued.
  2. All the non-key attributes must be fully functionally dependent on the key.
     ✗ **lastName**, **facId**, **schedule** and **room** are not fully functionally dependent on the key (**classNo**, **stuId**), so the table is not in 2NF.

NewClass

classNo	stuId	lastName	facId	schedule	room	grade
ART103A	S1001	Smith	F101	MWF9	H221	A
ART103A	S1010	Burns	F101	MWF9	H221	
ART103A	S1006	Lee	F101	MWF9	H221	B
CSC201A	S1003	Jones	F105	TuThF10	M110	A
CSC201A	S1006	Lee	F105	TuThF10	M110	C
HST205A	S1001	Smith	F202	MWF11	H221	

Solution → Second Normal Form (2NF)

Register

classNo	stuId	grade
ART103A	S1001	A
ART103A	S1010	
ART103A	S1006	B
CSC201A	S1003	A
CSC201A	S1006	C

Stu

stuId	lastName
S1001	Smith
S1010	Burns
S1006	Lee
S1003	Jones

Class2

classNo	facId	schedule	room
ART103A	F101	MWF9	H221
CSC201A	F105	TuThF10	M110
HST205A	F202	MWF11	H221

Third Normal Form (3NF)

- A table is in **third normal form (3NF)** if and only if,
  - It is the **second normal form (2NF)**,
  - No **transitive dependency** exists for non-key attributes.

Transitive Dependency:

IF A, B and C are attributes of Relation R, such that A → B and B → C, then C is transitively dependent on A.

Is This Table in 3NF?

NewStudent

stuId	lastName	major	credits	status
S1001	Smith	History	90	Senior
S1003	Jones	Math	95	Senior
S1006	Lee	CSC	15	Freshman
S1010	Burns	Art	63	Junior
S1060	Jones	CSC	25	Freshman

Is This Table in 3NF?

- Third normal form (3NF) rules,
  1. The table must be second normal form (2NF),
     - ✓ It is in 1NF, because all attributes (fields) are single-valued.
     - ✓ All the non-key attributes must be fully functionally dependent on the key.
  2. No transitive dependency must exist for non-key attributes.
     - ✗ **status** is dependent on **credits** of students, and **credits** is dependent on **stuId**, so there is transitive dependency for status on key. The table is not in 3NF.

NewStudent

stuId	lastName	major	credits	status
S1001	Smith	History	90	Senior
S1003	Jones	Math	95	Senior
S1006	Lee	CSC	15	Freshman
S1010	Burns	Art	63	Junior
S1060	Jones	CSC	25	Freshman

Solution → Third Normal Form (3NF)

NewStu2

stuId	lastName	major	credits
S1001	Smith	History	90
S1003	Jones	Math	95
S1006	Lee	CSC	15
S1010	Burns	Art	63
S1060	Jones	CSC	25

Stats

credits	status
15	Freshman
25	Freshman
63	Junior
90	Senior
95	Senior

Example – Normalize this table in Third Normal Form.

Teacher ID	courseName	course Type	teacher Name	Phone Number	numberOf StudentIn Course	student Feedback Score	feedback Status
20	Web Design	Core	John	312-555-1212, 312-561-1901	40	3	Neutral
21	Python	Core	Kate	310-677-1145	47	4	Good
21	Algorithms	Basic	Kate	310-677-1145	35	5	Very Good
20	Database	Core	John	312-555-1212, 312-561-1901	50	4	Good
24	English	Basic	William	122-331-0876	55	2	Bad

Answer – Normalize this table in Third Normal Form.

- In order to normalize a table in Third Normal Form (3NF), we need to make sure the table is normalized in 1NF and 2NF. Then the resulting normalized tables in 2NF are evaluated for 3NF.

TeacherID	courseName	courseType	teacherName	phoneNumber	numberOfStudent InCourse	student FeedbackScore	feedback Status
20	Web Design	Core	John	312-555-1212, 312-561-1901	40	3	Neutral
21	Python	Core	Kate	310-677-1145	47	4	Good
...	...	...	...	....	...	...	...

1NF

TeacherID	courseName	courseType	teacherName	phoneNumber	numberOfStudent InCourse	student FeedbackScore	feedback Status
20	Web Design	Core	John	312-555-1212	40	3	Neutral
20	Web Design	Core	John	312-561-1901	40	3	Neutral
...	...	...	...	....	...	...	...

2NF

Teacher ID	teacher Name	phone Number

Course Name	Course Type	numberOfStudent InCourse

Teacher ID	course Name	student FeedbackScore	feedback Status

3NF

Teacher ID	course Name	student FeedbackScore

student FeedbackScore	feedback Status