Convert Relations Into 3NF

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Overview

Learning Outcomes

By the end of this lecture, you should be able to

- Understand what is **2NF**.
- Convert 1NF relations into **2NF**.
- Know the problems of **2NF** relations.
- Understand what is **3NF**.
- Convert 2NF relations into **3NF**.
- Know the problems of **3NF** relations.

Second Normal Form

Second Normal Form

2NF:

- It is in 1NF.
- There is no non-key attributes B is partially dependent on a candidate key.
- No $C \rightarrow B$, where B is a set of non-key attributes, C is a strict subset of candidate key.

Attributes:

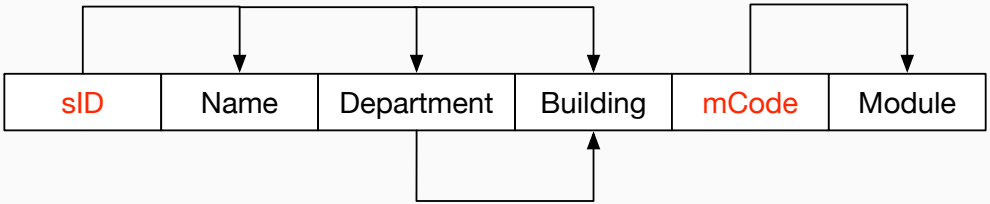
- Key attributes: part of some candidate key.
- Non-key attributes: the rest of the attributes.

Exercise 2: 2NF

sID	Name	Department	Building	mCode	Module
...	...	...	...	...	...

Is this relation in 2NF? If not, find the partial FDs on a candidate key.

Exercise 2: 2NF



- Candidate keys: $\{sID, mCode\}$
- Partial FDs:
  - $\{sID, mCode\} \rightarrow \{Module\}$
  - $\{sID, mCode\} \rightarrow \{Name, Department, Building\}$

Removing FDs

Suppose we have a relation R with schema S, a FD $A \rightarrow B$, where:

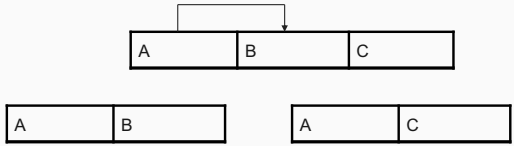
- A is a key attribute.
- $A \cap B = \{\}$

Let $C = S - (A \cup B)$, i.e., all other attributes.

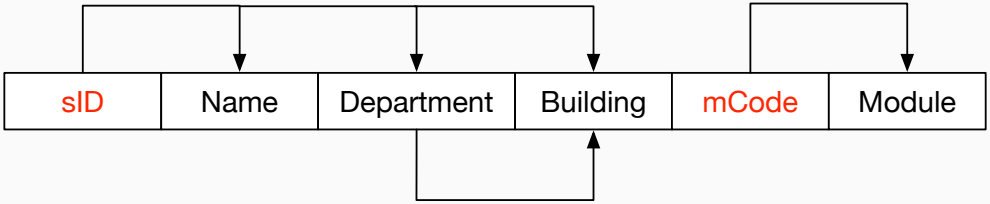
We could divide S into two parts:

- R_1, with schema $A \cup C$
- R_2, with schema $A \cup B$

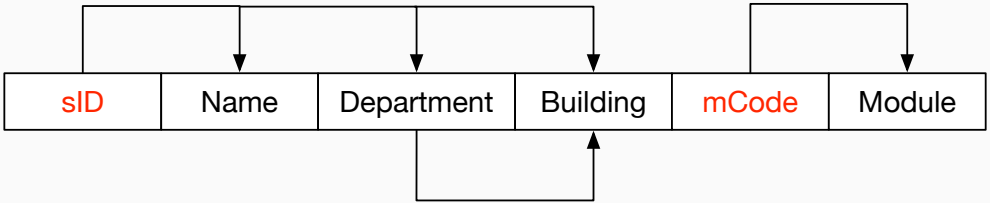
$S = R_1 \bowtie R_2$



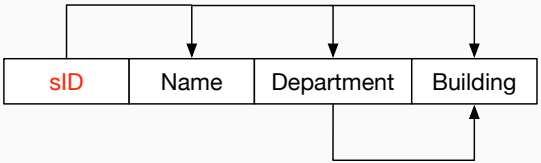
Exercise 3: Removing FDs



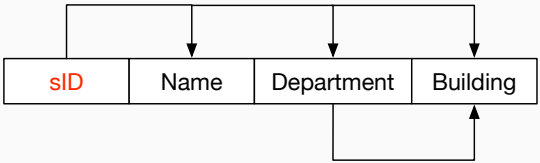
Exercise 3: Removing FDs



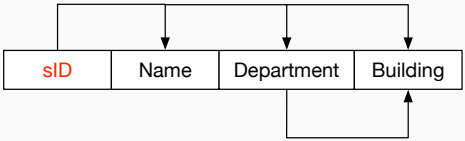
$A = sID$, $B = \{Name, Department, Building\}$, $C = \{mCode, Module\}$

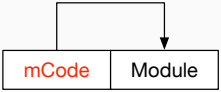


Exercise 3: Removing FDs



$A = mCode, B = \{Module\}, C = \{sID\}$





Example Database in 2NF

sID	Name	Department	Building
1	John Smith	Computer Science	B1
2	Mark Brown	Computer Science	B1
3	Mary Jones	Computer Science	B1
4	David Jones	Mathematics	A1

mCode	Module
DBI	Database and Interfaces
FAI	Foundation of Artificial Intelligence
PGA	Programming and Algorithms
MCS	Mathematics for Computer Scientists

sID	mCode
1	DBI
1	FAI
2	FAI
3	PGA
3	DBI
4	MCS

Recall the problems we have in 1NF

If we add a new staff David Ford in Computer Science with ID 5.

sID	Name	Department	Building
1	John Smith	Computer Science	B1
2	Mark Brown	Computer Science	B1
3	Mary Jones	Computer Science	B1
4	David Jones	Mathematics	A1

sID	mCode
1	DBI
1	FAI
2	FAI
3	PGA
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Insertion anomalies in 2NF

If we add a new staff David Ford in Computer Science with ID 5.

sID	Name	Department	Building
1	John Smith	Computer Science	B1
2	Mark Brown	Computer Science	B1
3	Mary Jones	Computer Science	B1
4	David Jones	Mathematics	A1
5	David Ford	Computer Science	?

sID	mCode
1	DBI
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Insertion anomalies in 2NF

If we add the department Chemistry that is in building C1.

sID	Name	Department	Building
1	John Smith	Computer Science	B1
2	Mark Brown	Computer Science	B1
3	Mary Jones	Computer Science	B1
4	David Jones	Mathematics	A1
Null	Null	Chemistry	C1

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Deletion anomalies in 2NF

If we want to delete module MCS

sID	Name	Department	Building
1	John Smith	Computer Science	B1
2	Mark Brown	Computer Science	B1
3	Mary Jones	Computer Science	B1
4	David Jones	Mathematics	A1

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Deletion anomalies in 2NF

If we want to delete module MCS

sID	Name	Department	Building
1	John Smith	Computer Science	B1
2	Mark Brown	Computer Science	B1
3	Mary Jones	Computer Science	B1
4	David Jones	Mathematics	A1

sID	mCode
1	DBI
1	FAI
2	FAI
3	PGA
3	DBI

mCode	Module
DBI	Database and Interfaces
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PGA	Programming and Algorithms

Deletion anomalies in 2NF

What if we want to delete David Jones?

sID	Name	Department	Building
1	John Smith	Computer Science	B1
2	Mark Brown	Computer Science	B1
3	Mary Jones	Computer Science	B1
4	David Jones	Mathematics	A1

sID	mCode
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Deletion anomalies in 2NF

Mary Jones is now transferred to the department of Mathematics

sID	Name	Department	Building
1	John Smith	Computer Science	B1
2	Mark Brown	Computer Science	B1
3	Mary Jones	Computer Science	B1
4	David Jones	Mathematics	A1

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Deletion anomalies in 2NF

Mary Jones is now transferred to the department of Mathematics

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3NF

Third Normal Form

sID	Name	Department	Building
1	John Smith	Computer Science	B1
2	Mark Brown	Computer Science	B1
3	Mary Jones	Computer Science	B1
4	David Jones	Mathematics	A1

- A special type of FDs: transitive FD.
  - $A \to C$ is a transitive FD, if there is some set B such that $A \to B$ and $B \to C$.
  - E.g., $\{sID\} \to \{Department\}$, $\{Department\} \to \{Building\}$
- Third Normal Form (3NF):
  - It is in 2NF.
  - No non-key attribute is transitively dependent on a candidate key.

Removing Transitive FDs

sID	Name	Department	Building
1	John Smith	Computer Science	B1
2	Mark Brown	Computer Science	B1
3	Mary Jones	Computer Science	B1
4	David Jones	Mathematics	A1

- If $A \rightarrow B$ and $B \rightarrow C$, S is the schema.
- Divide S into two parts:
  - R_1, with schema $B \cup C$.
  - R_2, with schema $S - C$.

Exercise 4: Removing transitive FDs

sID	Name	Department	Building
1	John Smith	Computer Science	B1
2	Mark Brown	Computer Science	B1
3	Mary Jones	Computer Science	B1
4	David Jones	Mathematics	A1

Exercise 4: Removing transitive FDs

sID	Name	Department
1	John Smith	Computer Science
2	Mark Brown	Computer Science
3	Mary Jones	Computer Science
4	David Jones	Mathematics

Department	Building
Computer Science	B1
Mathematics	A1

Example in 3NF

sID	Name	Department
1	John Smith	Computer Science
2	Mark Brown	Computer Science
3	Mary Jones	Computer Science
4	David Jones	Mathematics

Department	Building
Computer Science	B1
Mathematics	A1

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Insertion in 3NF

We want to add the department of Chemistry that is in building C1

sID	Name	Department
1	John Smith	Computer Science
2	Mark Brown	Computer Science
3	Mary Jones	Computer Science
4	David Jones	Mathematics

Department	Building
Computer Science	B1
Mathematics	A1

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Insertion in 3NF

We want to add the department of Chemistry that is in building C1

sID	Name	Department
1	John Smith	Computer Science
2	Mark Brown	Computer Science
3	Mary Jones	Computer Science
4	David Jones	Mathematics

Department	Building
Computer Science	B1
Mathematics	A1
Chemistry	C1

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Deletion in 3NF

We want to delete David Jones.

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3	Mary Jones	Computer Science
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Department	Building
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Mathematics	A1

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Deletion in 3NF

We want to delete David Jones.

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Department	Building
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2	FAI
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Update in 3NF

Mary Jones is now transferred to the department of Mathematics.

sID	Name	Department
1	John Smith	Computer Science
2	Mark Brown	Computer Science
3	Mary Jones	Computer Science
4	David Jones	Mathematics

Department	Building
Computer Science	B1
Mathematics	A1

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Update in 3NF

Mary Jones is now transferred to the department of Mathematics.

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3	Mary Jones	Mathematics
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Department	Building
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Mathematics	A1

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Summary

Normalization and Design

Normalization is related to Database Design

- A database should normally be in 3NF at least.
- If your design leads to a non-3NF database, then you might want to revise it.

When you find you have a non-3NF database

- Identify the FDs that are causing problems.
- Think if they lead to any insert, update or deletion anomalies.
- Try to remove them.

Summary

Normalization

- Definition
- Functional Dependencies
- Normal Forms
- 1NF, 2NF and 3NF