UWE Bristol University of the West of England

Presented by

Dr. Trupti Padiya

School of Computing and Creative Technologies

Advanced Databases UFCFU3-15-3

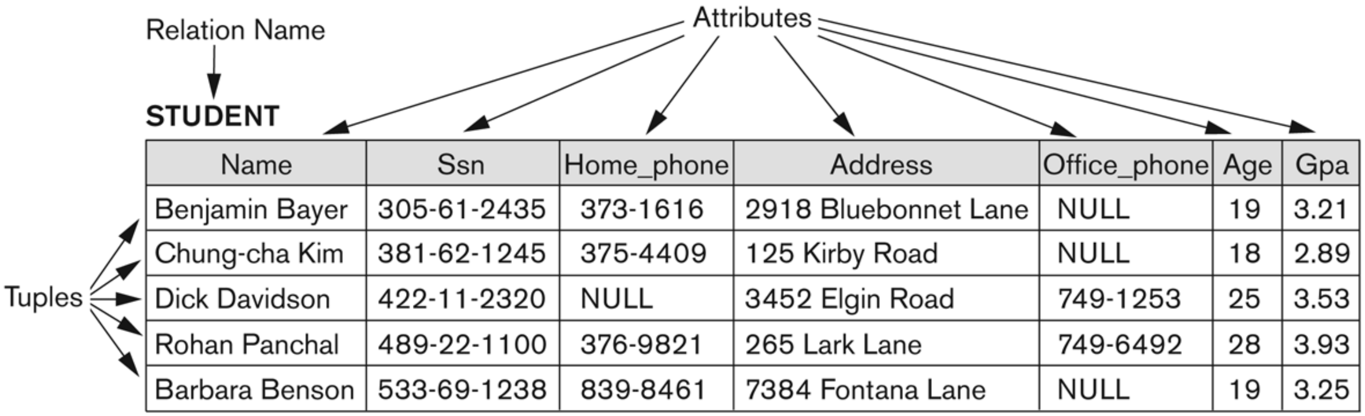
Relational databases, ER Modelling, and Normalization

Slides with modification adapted from Dr. Elias Pimenidis

Introduction - Database Management System

- A database management system
  - is a software system that enables users to define, create, maintain, and control access to the database
  - provides a systematic way to store, manage, and retrieve data
- In this module, we will look at both relational and no SQL databases

Relational Model



Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	NULL	19	3.21
Chung-cha Kim	381-62-1245	375-4409	125 Kirby Road	NULL	18	2.89
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	749-1253	25	3.53
Rohan Panchal	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	NULL	19	3.25

- All data is logically structured within relations (tables).
- Each relation has a name and is made up of named attributes (columns) of data.
- Each tuple (row) contains one value per attribute, representing a record

- Allows a high degree of data independence
- Provides substantial grounds for dealing with data semantics, consistency, and redundancy problems
- Enables the expansion of set-oriented data manipulation languages

Advantages of Relational Model

- Simplicity
- Flexibility
- Data Integrity
- Support for SQL
- Normalization

Database Design

- Conceptual
  - high-level representation of the data, usually using an Entity-Relationship Diagram (ERD)

- Logical
  - the process of transforming (or mapping) a conceptual schema of the application domain into a schema for the data model underlying a particular DBMS, e.g. relational

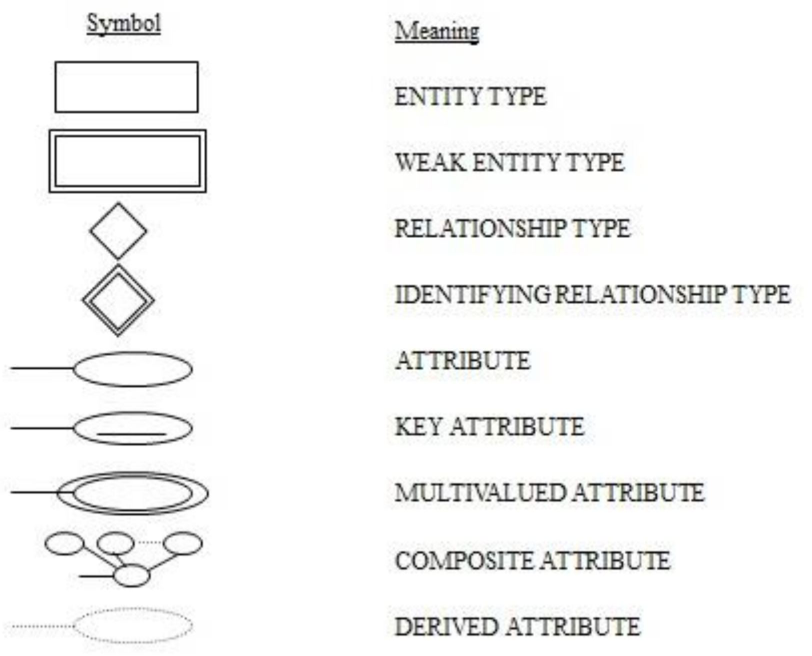
- Physical
  - the process of implementing a database's logical design on secondary storage using a specific DBMS

Entity Relationship Model (ER Model)

- Conceptual framework used for designing and structuring databases

- Key components of ERD:
  - Entity
    - Strong – typically has Primary key
    - Weak
  - Attributes
    - Simple
    - Composite
    - Derived
    - Multi-valued
  - Relationships and Cardinality
    - One to one (1:1)
    - One to Many (1:N)
    - Many to Many (M:N)
  - Participation constraints
    - Total
    - Partial

Entity Relationship Diagram Notations



Symbol

Meaning

ENTITY TYPE

WEAK ENTITY TYPE

RELATIONSHIP TYPE

IDENTIFYING RELATIONSHIP TYPE

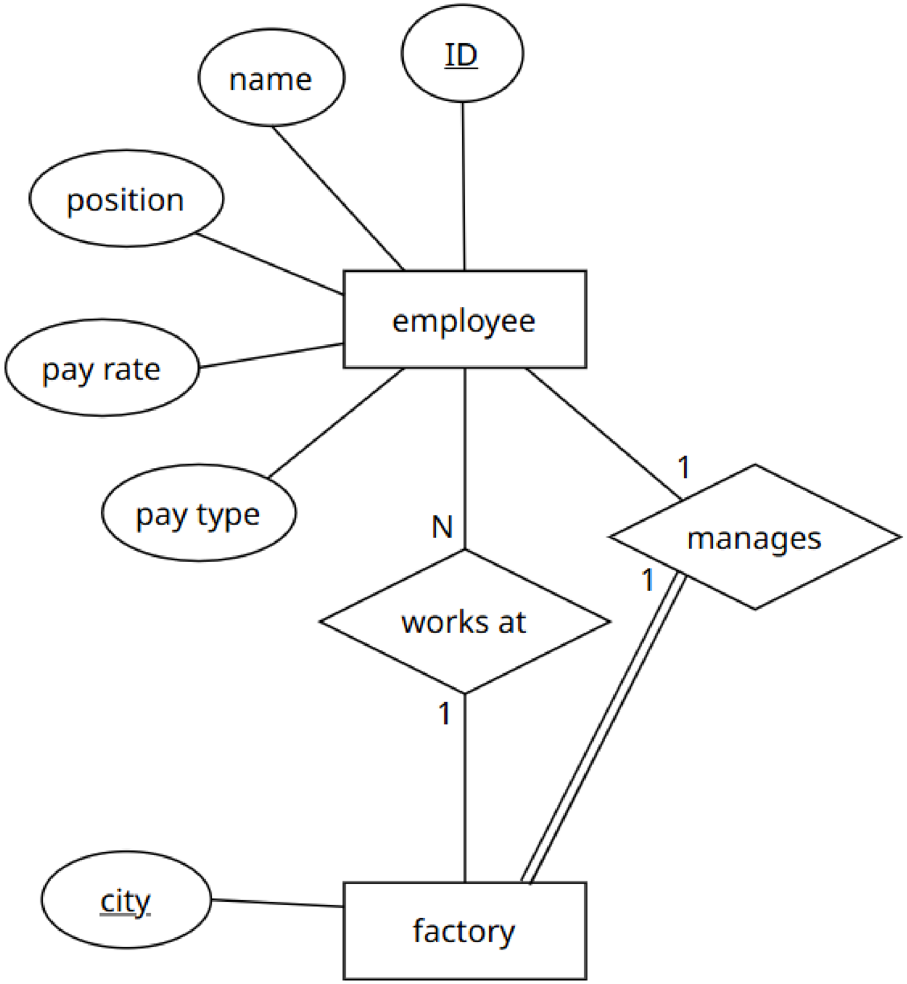
ATTRIBUTE

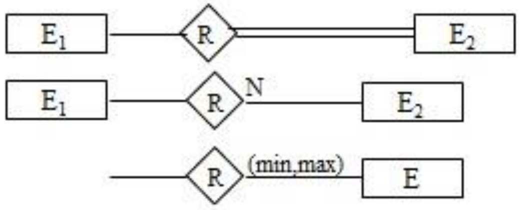
KEY ATTRIBUTE

MULTIVALUED ATTRIBUTE

COMPOSITE ATTRIBUTE

DERIVED ATTRIBUTE





TOTAL PARTICIPATION OF E_2 IN R

CARDINALITY RATIO 1:N FOR E_1:E_2 IN R

STRUCTURAL CONSTRAINT (min, max) ON PARTICIPATION OF E IN R

Normalization

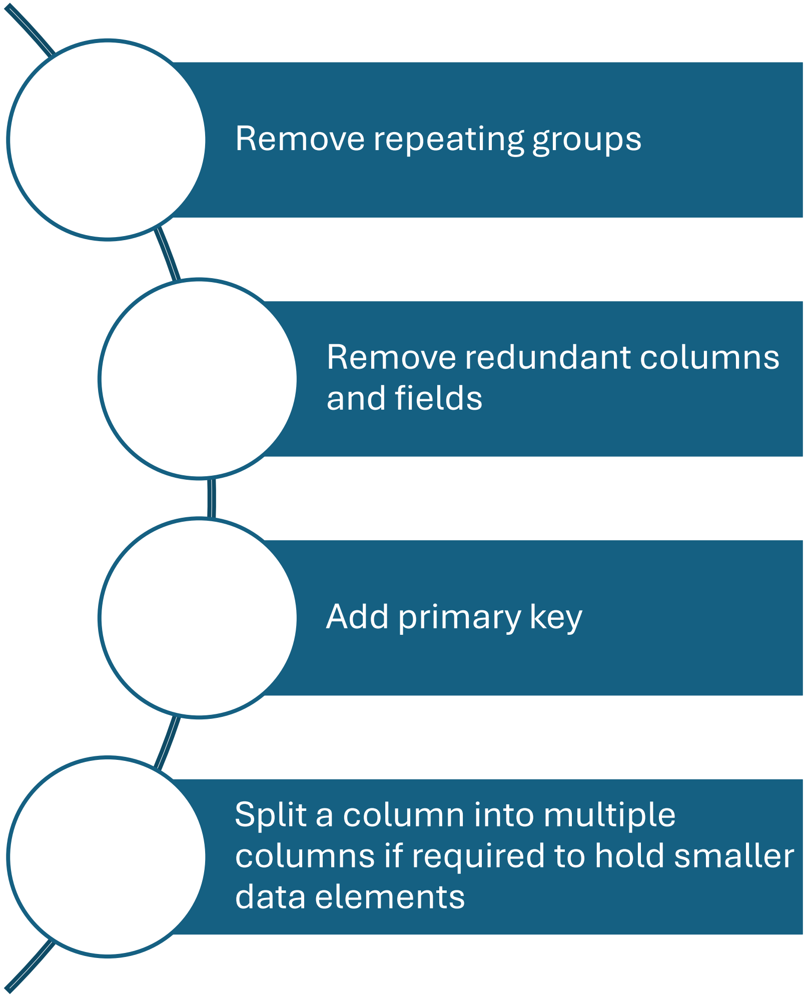
- A technique for producing a set of suitable relations that support the data requirements of an enterprise.
  - Reduces redundancy
  - Minimizes anomalies (Data inconsistencies)
  - Improves data integrity

https://learn.microsoft.com/en-us/office/troubleshoot/access/database-normalization-description

First Normal Form (1NF)

- No repeating group
- A repeating group is an attribute, or group of attributes, within a table that occurs with multiple values for a single occurrence of the nominated key attribute(s) for that table.
- Atomic data
- A relation in which the intersection of each row and column contains one and only one value.
- Primary key
    - Each record must have a unique identifier

How to convert from UNF to 1NF?



Remove repeating groups

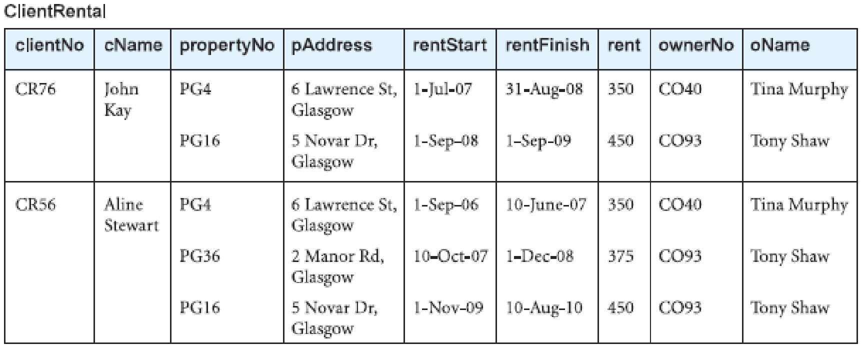
Remove redundant columns and fields

Add primary key

Split a column into multiple columns if required to hold smaller data elements

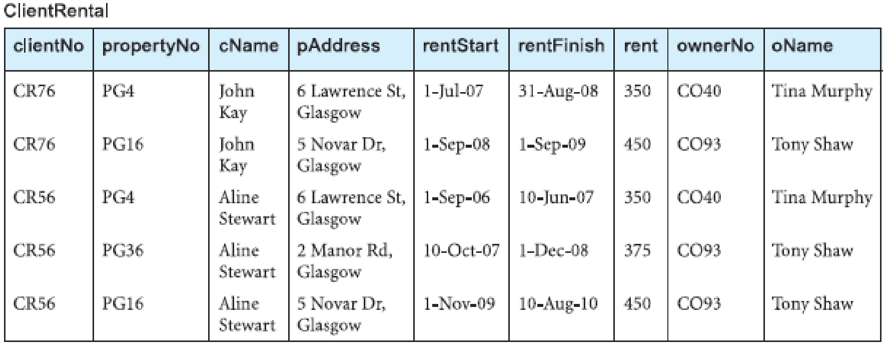
Example: UNF to 1 NF

- The repeating group in the unnormalized table as the property rented details, which repeats for each client.
- The structure of the repeating group is: Repeating Group = (propertyNo, pAddress, rentStart, rentFinish, rent, ownerNo, oName)
- Multiple values at the intersection of certain rows and columns. For example, there are two values for propertyNo(PG4 and PG16) for the client named John Kay.
- To transform an unnormalized table into 1NF, we ensure that there is a single value at the intersection of each row and column.



ClientRental

clientNo	cName	propertyNo	pAddress	rentStart	rentFinish	rent	ownerNo	oName
CR76	John Kay	PG4 PG16	6 Lawrence St, Glasgow 5 Novar Dr, Glasgow	1-Jul-07 1-Sep-08	31-Aug-08 1-Sep-09	350 450	CO40 CO93	Tina Murphy Tony Shaw
CR56	Aline Stewart	PG4 PG36 PG16	6 Lawrence St, Glasgow 2 Manor Rd, Glasgow 5 Novar Dr, Glasgow	1-Sep-06 10-Oct-07 1-Nov-09	10-June-07 1-Dec-08 10-Aug-10	350 375 450	CO40 CO93 CO93	Tina Murphy Tony Shaw Tony Shaw



ClientRental

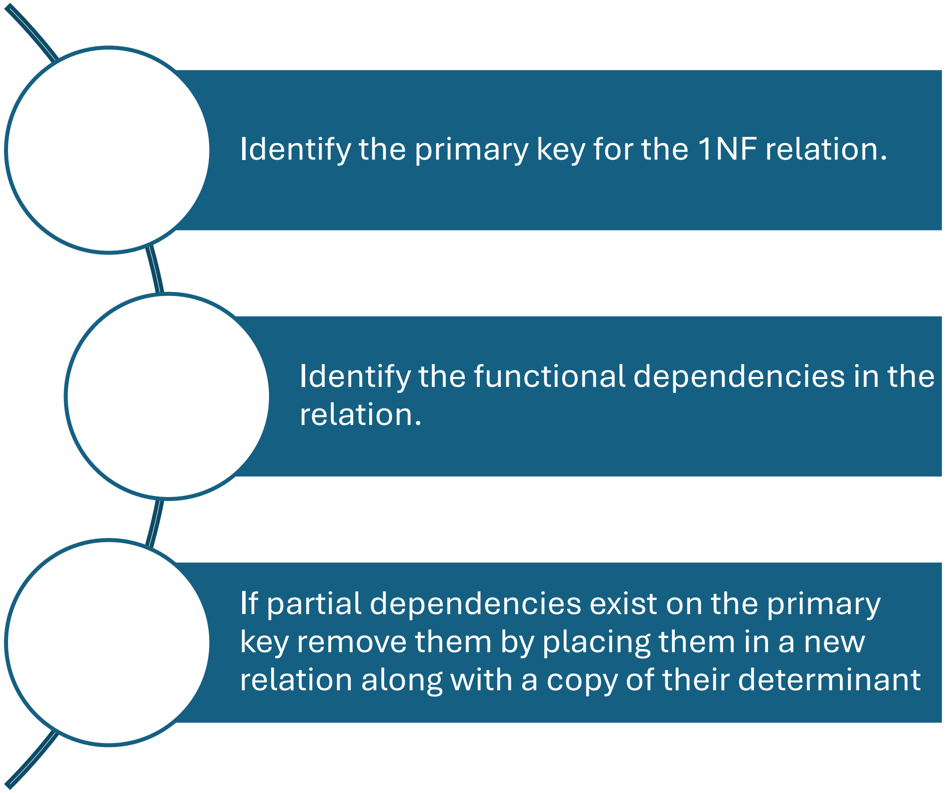
clientNo	propertyNo	cName	pAddress	rentStart	rentFinish	rent	ownerNo	oName
CR76	PG4	John Kay	6 Lawrence St, Glasgow	1-Jul-07	31-Aug-08	350	CO40	Tina Murphy
CR76	PG16	John Kay	5 Novar Dr, Glasgow	1-Sep-08	1-Sep-09	450	CO93	Tony Shaw
CR56	PG4	Aline Stewart	6 Lawrence St, Glasgow	1-Sep-06	10-Jun-07	350	CO40	Tina Murphy
CR56	PG36	Aline Stewart	2 Manor Rd, Glasgow	10-Oct-07	1-Dec-08	375	CO93	Tony Shaw
CR56	PG16	Aline Stewart	5 Novar Dr, Glasgow	1-Nov-09	10-Aug-10	450	CO93	Tony Shaw

Second Normal Form (2NF)

A relation that is in first normal form and every non-primary-key attribute is fully functionally dependent on any candidate key.

- A relation in 2NF **must be**
  - in 1NF and
  - every non-primary-key attribute is fully functionally dependent on the primary key.

How to convert from 1NF to 2NF?



Identify the primary key for the 1NF relation.

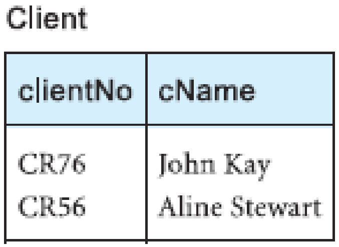
Identify the functional dependencies in the relation.

If partial dependencies exist on the primary key remove them by placing them in a new relation along with a copy of their determinant

1NF to 2NF

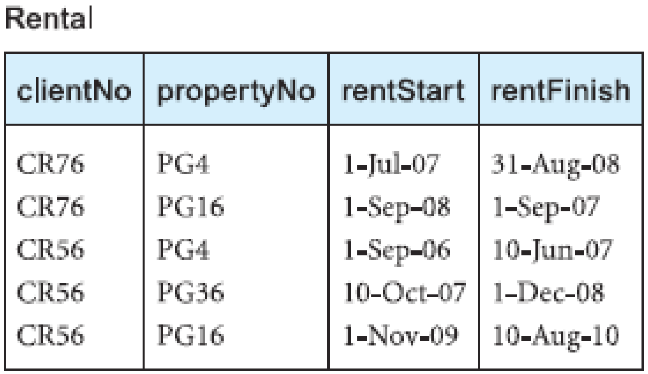
- This results in the creation of three new relations called Client, Rental, and PropertyOwner,

- These three relations are in second normal form, as every non-primary-key attribute is fully functionally dependent on the primary key of the relation.



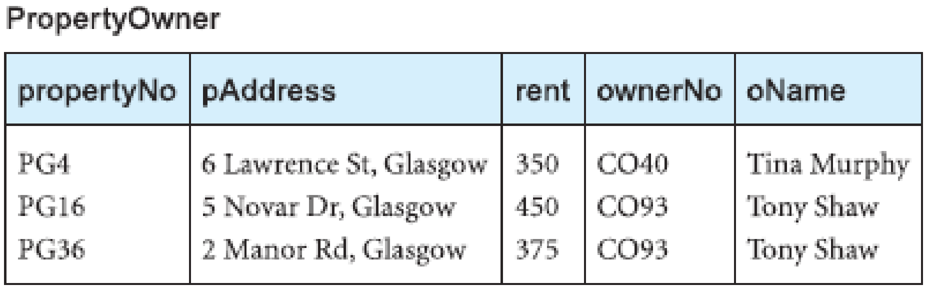
Client

clientNo	cName
CR76	John Kay
CR56	Aline Stewart



Rental

clientNo	propertyNo	rentStart	rentFinish
CR76	PG4	1-Jul-07	31-Aug-08
CR76	PG16	1-Sep-08	1-Sep-07
CR56	PG4	1-Sep-06	10-Jun-07
CR56	PG36	10-Oct-07	1-Dec-08
CR56	PG16	1-Nov-09	10-Aug-10



PropertyOwner

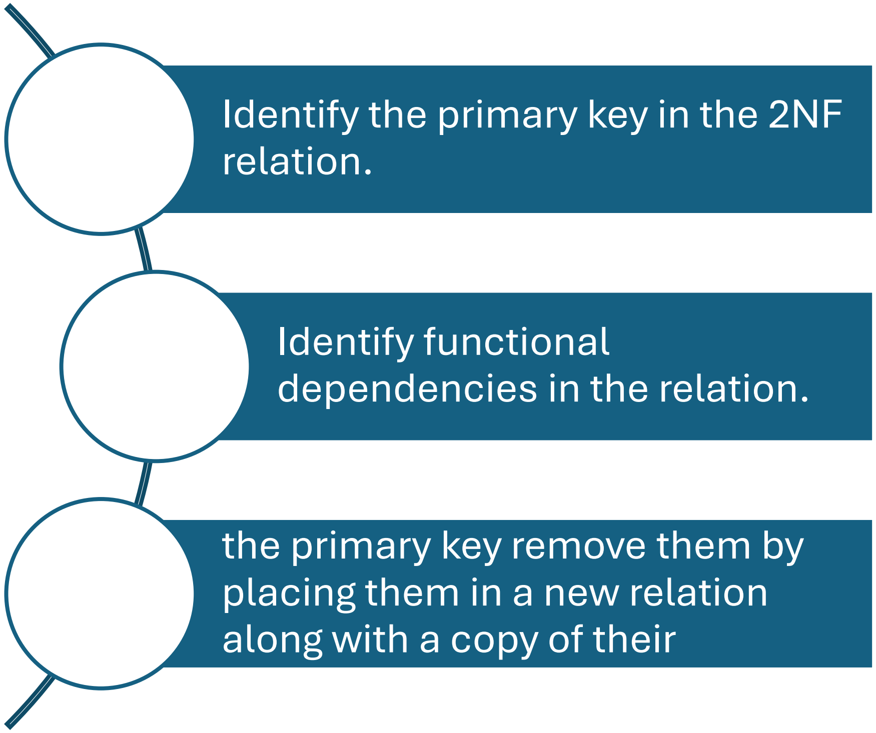
propertyNo	pAddress	rent	ownerNo	oName
PG4	6 Lawrence St, Glasgow	350	CO40	Tina Murphy
PG16	5 Novar Dr, Glasgow	450	CO93	Tony Shaw
PG36	2 Manor Rd, Glasgow	375	CO93	Tony Shaw

Third Normal Form (3NF)

A relation that is in first and second normal form and in which no non-primary-key attribute is transitively dependent on any candidate key

- Based on the concept of transitive dependency.
- Transitive Dependency is a condition where
  - A, B and C are attributes of a relation such that if A ->B and B ->C,
  - then C is transitively dependent on A through B. (Provided that A is not functionally dependent on B or C).

How to convert from 2NF to 3NF?



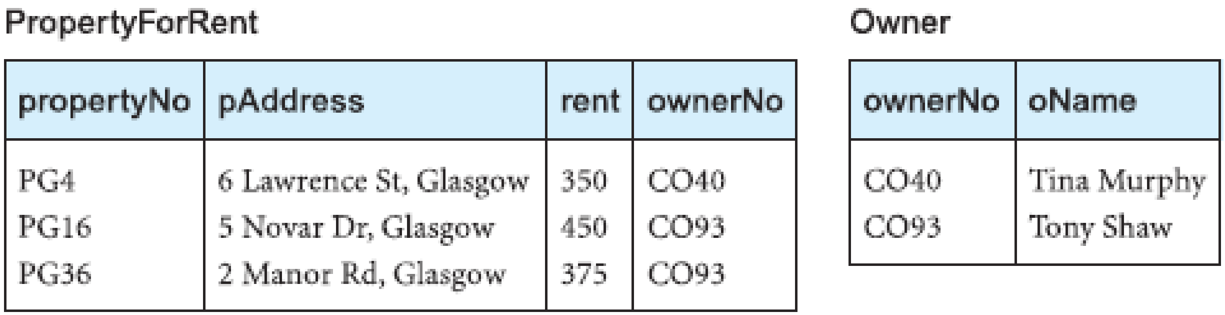
Identify the primary key in the 2NF relation.

Identify functional dependencies in the relation.

the primary key remove them by placing them in a new relation along with a copy of their

2NF to 3NF

- To transform the PropertyOwnerrelation into 3NF, we must first remove this transitive dependency by creating two new relations called **PropertyForRent** and **Owner**



PropertyForRent

propertyNo	pAddress	rent	ownerNo
PG4	6 Lawrence St, Glasgow	350	CO40
PG16	5 Novar Dr, Glasgow	450	CO93
PG36	2 Manor Rd, Glasgow	375	CO93

Owner

ownerNo	oName
CO40	Tina Murphy
CO93	Tony Shaw

Passive DBMSs vs Active DBMSs

- Conventional DBMSs are **passive**: they execute operations only upon explicit requests
- Often, however, there is the need of **reactive** capabilities: the DBMS autonomously reacts to some events and executes specified operations
- We refer to them as **activeDBMS (ADBMS)** for which we can specify *active rules*, also called ***triggers***

Applications for Active Databases

- Logging/tracking events
- Security
- Notification
  - Automatic notification when certain condition occurs
- Enforcing business constraints/rules
- Maintenance of derived data
  - Automatically update derived data and avoid anomalies due to redundancy e.g.trigger to update the Total salary in a department
- Maintain replicated tables

Triggers

- A trigger is a statement that is executed automatically by the DBMS as a side effect of a modification to the database
- A trigger describes an action the database should take under certain conditions when some database-related event (such as inserts, updates, deletes) occurs.

Event-Condition-Action (ECA) Model

- The model that has been used to specify active database rules is referred to as Event-Condition-Action (ECA) model

- **ON *event* IF *condition* THEN *action***

- **Event(s)** that trigger the rule to be checked: e.g. insert, delete, update
- **Condition** that determines whether the action should be executed: A logical expression (true/false)
  - Optional: If no condition is specified then condition is always true
- **Action:** Sequence of SQL statements and code to be executed

Triggers –An Example

```
create triggeroverdraft_trigger
after update on account
referencing new row as nrow
for each row
        when: nrow.balance < 0
        begin atomic
                insert into borrower
                (select customer_name, account_number From depositor
                where:nrow.account_number= depositor.account_number);

                insert into loan values
                (:nrow.account_number, :nrow.branch_name, :nrow.balance);
                update account setbalance = 0
                where account.account_number= :nrow.account_number
        end
```

Resources – some helpful links for further learning

- Reading list: UFCFU3-15-3 Advanced Databases | UWE Bristol
- https://www.w3schools.com/mysql/mysql_rdbms.asp
- https://cloud.google.com/learn/what-is-a-relational-database
- https://learn.microsoft.com/en-us/office/troubleshoot/access/database-normalization-description
- Normalization: https://www.youtube.com/watch?v=Yp82NgeQZ9o