

Level: Second Year Bachelor in Computer Science (2024/2025)

Module: Information Systems

Exercise Series No. 9 (LDM - Logical Data Model)

Exercise 1:

- Propose logical data models for the conceptual data models (CDMs) established in the 6th exercise series.
- Are the resulting relations in the Third Normal Form (3NF)?

Exercise 2:

Given the relation:

Projection (*FilmID*, *FilmTitle*, *FilmDuration*, *RoomID*, *RoomCapacity*, *SeatType*, *SeatPrice*, *ProjectionDate*, *StartTime*)

This relation expresses that the film with ID *FilmID* titled *FilmTitle* has a duration of *FilmDuration* hours and is screened in room *RoomID*, which has a capacity of *RoomCapacity* seats. The film is screened on *ProjectionDate* at *StartTime*. Two films can share the same title. The price of a seat (*SeatPrice*) depends on its type (*SeatType*).

- Deduce a relational schema in 3NF.

Exercise 3:

The following relation describes orders placed by clients, with the products and quantities ordered by each client:

Orders (*OrderID*, *OrderDate*, *ClientID*, *ClientAddress*, *ProductID*, *ProductPrice*, *Quantity*)

- What is the key of this relation?
- In which normal form is it?
- Transform it in 3NF if it's not

SOLUTIONS

Exercise 1

LDM 1 (Logical Data Model 1)

- **Student** (StudentID, St_LastName, St_FirstName, EnrollmentDate, ProgramID*, ProjectID*)
- **Program** (ProgramID, ProgramName)
- **Project** (ProjectID, ProjectTitle, JuryID, DefenseDate)
- **Jury** (JuryID, ProfessorId*) ——— ProfessorId of the president
- **Professor** (ProfessorId, Pr_LastName, Pr_FirstName)
- **Participates** (ProfessorID, JuryID)

Normalization Verification:

- All attributes are atomic and simple → the relations are in the **1st Normal Form (1NF)**.
- There is only one case of a relation with a composite key (*Part_of*), and no non-key attribute depends on a part of the composite key → the relations are in the **2nd Normal Form (2NF)**.
- In all relations, there are no functional dependencies between non-key attributes → the relations are in the **3rd Normal Form (3NF)**.

LDM 2 (Logical Data Model 2)

- **Individuals** (*IdentityNumber, LastName, FirstName, DateOfBirth, PhoneNumber*)
- **Municipality** (*MunicipalityID, MunicipalityName, DistanceFromAgency, Population*)
- **Neighborhood** (*NeighborhoodID, NeighborhoodName, MunicipalityID*)
- **Accommodation** (*AccommodationID, Address, Area, Price, AccommodationType, NeighborhoodID**)
- **AccommodationTypes** (*AccommodationType, FlatRateFee*)
- **Rental** (*RentalID, StartDate, EndDate, IdentityNumber*, AccommodationID**)

Normalization Verification:

- All attributes are atomic and simple, including the *Address* attribute in the *Accommodation* relation, since neighborhoods and municipalities are independent → the relations are in the **1st Normal Form (1NF)**.

- There are no relations with composite keys → the relations are in the **2nd Normal Form (2NF)**.
- In all relations, there are no functional dependencies between non-key attributes → the relations are in the **3rd Normal Form (3NF)**.

LDM 3 (Logical Data Model 3)

- Project (**Buil Permit number**, Area, Adress, Start_date, Duration, ClientId*, Bus_Red_Num*)
- Architect (**Bus Reg Num**, Arch_First_name, Arch_Last_name, Arch_Phone_num)
- Worker (**Worker Id**, Work_First_name, Work_Last_name, Work_Phone_num, Spec_Num*)
- Speciality (**Spec Num**, Spec_Design Salary)
- Client (**Client Id**, Cl_First_name, Cl-Last_name, Cl_Phone_num)
- Work_In (**Worket Id, Bui Permit number**)

Normalization Verification:

- All attributes are atomic and simple → the relations are in the **1st Normal Form (1NF)**.
- There is only one case of a relation with a composite key (*Work_In*), and no non-key attribute depends on a part of the composite key → the relations are in the **2nd Normal Form (2NF)**.
- In all relations, there are no functional dependencies between non-key attributes → the relations are in the **3rd Normal Form (3NF)**.

Exercise 2

List of Functional Dependencies:

1. **FilmID → FilmTitle, FilmDuration**
2. **RoomID → RoomCapacity**
3. **FilmID, ProjectionDate → RoomID**
4. **FilmID, ProjectionDate → StartTime**

5. **RoomID, SeatType** → **SeatPrice**

Resulting Schema in 3NF:

- **Films** (**FilmID**, FilmTitle, FilmDuration)
- **Rooms** (**RoomID**, RoomCapacity)
- **Projections** (**FilmID, ProjectionDate**, RoomID*, StartTime)
- **Seats** (**RoomID, SeatType**, SeatPrice)

Exercise 3

Orders (*OrderID, OrderDate, ClientID, ClientAddress, ProductID, ProductPrice, Quantity*)

Before determining the key, we must first identify the functional dependencies (FDs). The problem statement does not specify any management rules, but we can assume the following:

1. **OrderID** → **OrderDate, ClientID, ClientAddress**
(An order is placed by a single client with a given address on a given date.)
2. **OrderID, ProductID** → **ProductPrice, Quantity**
(In an order, a product has a given price and is ordered in a given quantity.)
3. **ClientID** → **ClientAddress**
(A client has only one address.)
4. **ProductID** → **Price**
(A product has only one price.)

By transitivity, we can then conclude that **(OrderID, ProductID)** determines all other attributes, making it a key.

2- Normalization verification

- All attributes are atomics → the relation is on 1NF

- We notice that ProductPrice functionally depends on part of the key, which is ProductID, and similarly, ClientID, OrderDate, and ClientAddress depend on part of the key, which is OrderID. Therefore, the relation is not in 2NF
- We notice that ClientAddress, which is a non-key attribute, depends on another non-key attribute, ClientID. Therefore, the relation is not in 3NF.

3- Transformation of the relation on 3NF

Client (**ClientID**, ClientAddress)

Product (**ProductID**, ProductPrice)

Order (**OrderID**, OrderDate, **ClientID***)

Order_Content (**OrderID**, **ProductID**, Quantity)