University of Mila | Department of Computer Science
2nd undergraduate year | Database Course
Academic year : 2025-2026 | Teacher : F.Benabderrahmane

Directed Work Series N°2

Exercise 1: : Simplified Management of a Children's Sports Club

A sports club offers activities for children. We consider the following relation:

R_1(CodeChild, FirstName, Age, Activity, Coach, TrainingDay)

Sample Relation R1 :

CodeChild	FirstName	Age	Activity	Coach	TrainingDay
1	Karim	6	Football	Yassine	Monday
2	Sami	6	Football	Yassine	Monday
3	Inès	7	Swimming	Nabila	Wednesday
4	Yasmine	7	Swimming	Nabila	Wednesday
5	Adam	6	Judo	Samir	Thursday
6	Mehdi	6	Judo	Samir	Thursday
7	Lina	7	Gymnastics	Sarah	Friday

Business Rules

1. Each child is uniquely identified by **CodeChild**. A child has exactly one first name and one age.
2. Each child practices **only one activity**.
3. Each activity is reserved for children of a **single age**.
4. Each activity is supervised by **one coach only**.
5. Each activity takes place on a **fixed training day** each week.
6. A coach supervises **only one activity**.

Questions:

1. Determine the functional dependencies using the business rules and the provided data.
2. Determine the primary key of the relation.
3. Construct the Functional Dependency Graph (FDG).

Exercise 2: Extended Management with Historical Tracking

The club now wishes to maintain the history of children's registrations over time. A child may change activity from one year to another. However, during a given year, a child is enrolled in only one activity.

Consider the following relation:

R_2(CodeChild, FirstName, Age, Year, Activity, Coach, TrainingDay, TimeSlot, Room)

Note: The attribute **Age** represents the age of the child during the corresponding registration year.

Business Rules

1. Each child is uniquely identified by **CodeChild**. A child has exactly one first name.

2. A child may change activity from one year to another. However, for a given year, a child is enrolled in **only one activity**.
3. The attribute **Age** corresponds to the child's age during the registration year.
4. Each activity has an assigned coach. A coach may supervise multiple activities.
5. Each activity is scheduled with a fixed training day, time slot, and room (for the purpose of this exercise).
6. A room cannot host more than one activity at the same time (same training day and same time slot).

Sample Relation R2

CodeChild	FirstName	Age	Year	Activity	Coach	TrainingDay	TimeSlot	Room
1	Karim	6	2024	Football	Yassine	Monday	16:00	A1
1	Karim	7	2025	Judo	Samir	Thursday	17:00	C3
2	Sami	6	2024	Football	Yassine	Monday	16:00	A1
2	Sami	7	2025	Football	Yassine	Monday	16:00	A1
3	Inès	7	2024	Swimming	Nabila	Wednesday	15:00	B2
4	Yasmine	7	2024	Swimming	Nabila	Wednesday	15:00	B2
5	Adam	6	2024	Judo	Samir	Thursday	17:00	C3
6	Mehdi	6	2024	Judo	Samir	Thursday	17:00	C3

Questions

1. Determine the functional dependencies using the business rules and the provided data.
2. Determine the primary key of the relation.
3. Construct the Functional Dependency Graph (FDG).
4. Compute the closure of {CodeChild} and explain why it is no longer a key.
5. Decompose the relation into Third Normal Form (3NF).

Exercise3 : Proving Functional Dependencies Using Armstrong's Axioms

Consider the relation: $R(A, B, C, D, E, F, G)$
with the following set of functional dependencies:

$$F = \{A \to BC,\ B \to D,\ CD \to E,\ E \to F,\ F \to G,\ AG \to D\}$$

Question1 : For each of the following dependencies, prove that it is derivable from F:

1. $A \to D$
2. $A \to E$
3. $A \to FG$

4. $AC \rightarrow E$
5. $AB \rightarrow EG$

Each proof must be written step by step, citing the rule used from Armstrong Axioms and derived rules

Question2 : For each of the following dependencies, determine whether it is derivable from F.

If it is not derivable, justify logically why not.

6. $B \rightarrow E$
7. $C \rightarrow E$
8. $D \rightarrow F$

Exercise 4: Attribute Closure and Candidate Keys :

Consider the relation:

$$R(A, B, C, D, E, F, G, H)$$

and the following set of functional dependencies:

$$F = \{A \rightarrow B,\ B \rightarrow C,\ CD \rightarrow E,\ E \rightarrow F,\ F \rightarrow G,\ G \rightarrow D,\ AH \rightarrow C\}$$

Questions

a) Compute the closure of {A}, denoted A^+.

b) Does attribute D belong to A^+? Justify your answer.

c) Compute the following closures:

- $(A, H)^+$
- $(A, D)^+$
- $(A, E)^+$
- $(A, H, D)^+$

d) Is the set {A, H} a key for R? Justify rigorously.

e) Determine all candidate keys of relation R

Exercise 5: Private Clinic Medical Records Management

A private clinic wishes to organize the medical records of its patients. Each patient is followed by a primary (reference) physician and may undergo several examinations in the clinic. Each patient is identified by a **PatientID** and has a **LastName**, **FirstName**, and **DateOfBirth**. Each physician is identified by a **DoctorID** and has a **LastName** and a **Specialty**.

Business Rules:

1. Each patient has only one primary physician, but one physician may follow several patients.
2. A patient may undergo several medical examinations, each on a given date; an examination has a conclusion and an **ExamType**.
3. An examination is associated with only one patient and only one primary physician.

4. The same **ExamType** always has the same cost.

Questions:

1. Determine the universal relation (UR) that groups all the information.
2. Identify the functional dependencies (FDs) from the business rules.
3. Find the transitive closure of **PatientID** and **ExamCode**.
4. Determine the primary key of the UR.
5. Find a minimal cover of the functional dependencies.
6. What is the normalization level (normal form) of the UR? Justify your answer.
7. Decompose the UR into **3NF**.

Exercise 6 : Hotel Reservation Management (Additional)

A hotel wishes to structure its database to manage its reservations and customers.

Each customer is identified by a **CustomerID** and has a **LastName**, **FirstName**, and **Address**. Each hotel room is identified by a **RoomNumber** and belongs to a **RoomCategory** (standard, deluxe, suite). A **RoomCategory** has a unique nightly rate. A customer may make several reservations, identified by a **ReservationID**, and one reservation may include several rooms. Each reservation has a **StartDate**, **EndDate**, and a **Status** (confirmed, canceled, pending). A room can be reserved only once for the same period.

Questions:

1. Determine the universal relation (UR).
2. Identify the functional dependencies (FDs).
3. Find the transitive closure of **ReservationID** and **RoomNumber**.
4. Determine the primary key.
5. Find a minimal cover of the functional dependencies.
6. What is the normalization level (normal form) of the UR? Justify your answer.
7. Decompose the UR into **3NF**.