Department of Computer Science

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Databases I
Summer Semester 2024

Exam
25.06.2024

Name: _____ **Student ID:** _____

Hints

- Check whether you received all pages of the exam (13 pages).
- Write your name or your student ID on each sheet of the exam and hand in all pages.
- All answers are expected to be written on the exam sheets.
- Clearly highlight and enumerate additional pages that are used for longer answers. Match your text with the according exercise.
- Only use pencils that are permanent and non-red colored.
- Use the notation and techniques discussed in the lecture.
- Exercises with more than one solution are not graded.
- You are allowed to use one A4 sheet with your personal notes (both sides, hand written or printed).
- Exam duration: 90 minutes

Signature _____

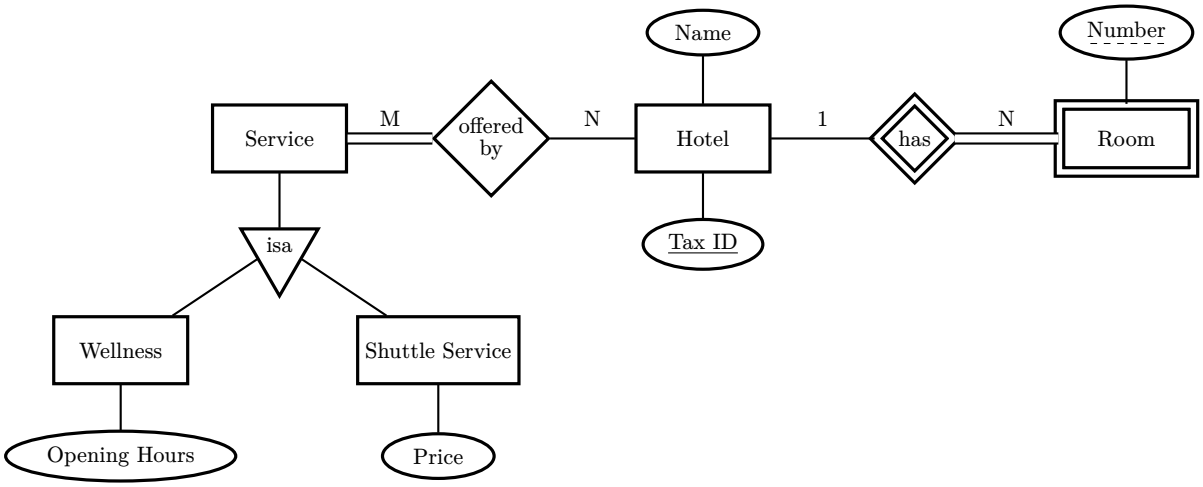
Grading

Filled by the examiner

Exercise	1	2	3	4	5	6	7	8	9	Sum
Total points	1	1	1	1	1	1	1	1	1	9
Points reached										

Exercise 1 — 1 Point

Mark the following statements as true (**T**) or false (**F**) with respect to the given ER-diagram. Incorrect answers will result in points being deducted!



1. There can be hotels which offer no services. ☐
2. There can be more than one hotel with the same name. ☐
3. Every service has a price. ☐
4. There can be services which are neither wellness nor a shuttle service ☐
5. A service can be wellness and shuttle at once. ☐
6. There may be rooms with the same number in different hotels. ☐
7. There can be a room without a hotel. ☐
8. A hotel must have at least one room. ☐

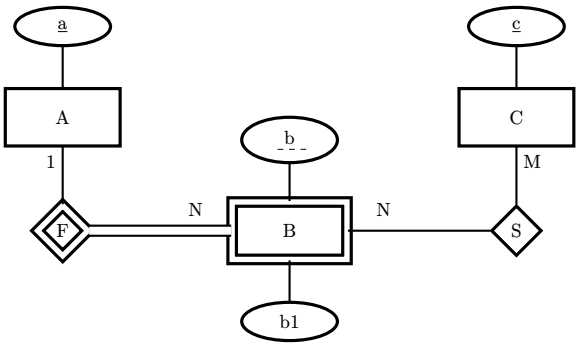
Exercise 2 — 1 Point

Create an **ER diagram** that meets the following requirements:

1. A person has a unique social security number (SSN), a name, and a date of birth.
2. A person must be either a coach, a therapist, or a player.
3. A coach has a license number, a therapist has a room number, and a player has a position.
4. A person must belong to exactly one team.
5. A team has a unique name and a budget.
6. Each team can have several people.
7. A stadium has a unique name and a capacity.
8. Two teams play against each other on a date in a stadium.

Exercise 3 — 1 Point

Translate the following ER-diagram into a **relational schema** and state all **foreign key constraints** using projection and subset operations.



Relational Schema (0.5 Punkte)

Foreign Key Constraints (0.5 Punkte)

This schema is used for the following exercises

Relational schema

Superhero(<u>hero_name</u>, firstname, lastname, birthplace)

Mission(<u>mission_id</u>, description, priority, time)

City(<u>stadt_name</u>, state, population)

MissionAssignment(<u>mission_id</u>, <u>hero_name</u>, <u>city_name</u>)

Foreign keys

$\pi_{\text{birthplace}}(\text{Superhero}) \subseteq \pi_{\text{city\_name}}(City)$

$\pi_{\text{hero\_name}}(\text{MissionAssignment}) \subseteq \pi_{\text{hero\_name}}(Superheld)$

$\pi_{\text{mission\_id}}(\text{MissionAssignment}) \subseteq \pi_{\text{mission\_id}}(Mission)$

$\pi_{\text{city\_name}}(\text{MissionAssignment}) \subseteq \pi_{\text{city\_name}}(City)$

Database instance for the following exercises

City

city_name	state	population
Berlin	Germany	4M
Dayton	US	140500
Gotham	US	30M
Kandor	Krypton	8M
Manhattan	US	2M
Metropolis	US	23M
Stalingrad	Russia	1M
Tokyo	Japan	10M
Waverly	US	10000

MissionAssignment

mission_id	hero_name	city_name
1	Batman	Gotham
57	Black Widow	Dayton
81	Superman	Metropolis
196	Captain America	Berlin
272	Hulk	Manhattan
272	Iron Man	Manhattan
272	Captain America	Manhattan
272	Black Widow	Manhattan
521	Iron Man	Waverly

Superhero

hero_name	firstname	lastname	birthplace
Batman	Bruce	Wayne	Gotham
Black Widow	Natasha	Romanoff	Stalingrad
Captain America	Steven	Rogers	Manhattan
Hulk	Bruce	Banner	Dayton
Iron Man	Tony	Stark	Manhattan
Superman	Kal	El	Kandor
Hawkeye	Clinton	Barton	Waverly

Mission

mission_id	description	priority	time
1	Vanquish the nefarious Joker	8	3.10.2008
57	Pacify the formidable Hulk	7	28.9.2010
81	Rescue the intrepid Lois Lane	7	19.7.1968
196	Combat the insidious Hydra organization	9	2.4.1944
272	Thwart the omnipotent Thanos	10	8.7.2019
521	Liberate the captive Pepper Potts	7	11.12.2022

The space above and below the message intentionally is left blank.

Exercise 4 — 1 Point

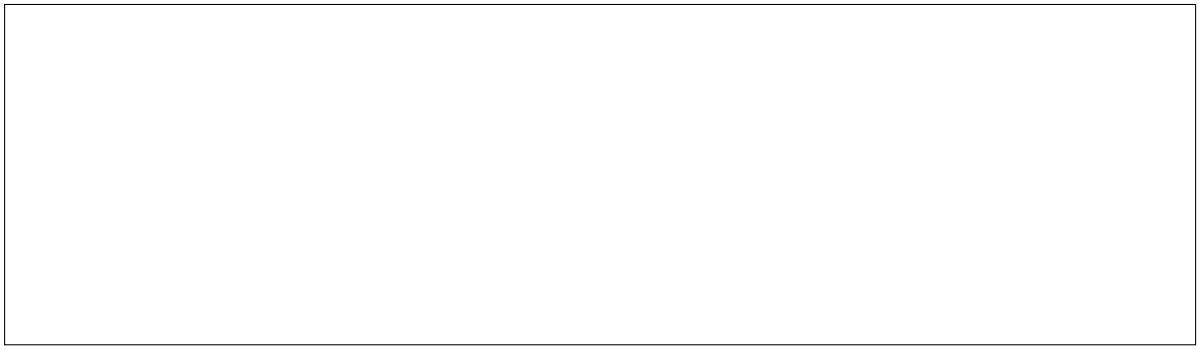
The following query is given in **relational algebra**:

$$\pi_{\text{hero\_name}}(\text{Superhero}) - \pi_{\text{hero\_name}}(\text{MissionAssignment})$$

Describe in natural language (in 1-2 sentences) what the query calculates.

Provide the result based on the example instance.

Provide a query in extended relational algebra that calculates the following: *List the name and state of all cities where there are no missions.*



Exercise 5 — 1 Point

Formulate the following query using **SQL**. Pay attention to syntactic correctness. The data in the instance on page 5 are exemplary. Therefore, always provide universally valid solutions.

List all hero names (without duplicates) that are assigned to a mission after timestamp '1.1.2019'.

Exercise 6 — 1 Point

Formulate the following query using **SQL**. Pay attention to syntactic correctness. The data in the instance on page 5 are exemplary. Therefore, always provide universally valid solutions.

1. List all hero names (`hero_name` attribute) whose `first name` and `last name` together contain more than 7 letters. (**0.4P**)

Note: The function length() determines the number of letters in an attribute value.

2. Determine the average mission priority of all missions per year. Only missions in which Batman did not participate are considered. (**0.6P**)

Note: The function year() determines the year of a date value.

Exercise 7 — 1 Point

Consider relation $R[A, B, C, D, E]$ with the following functional dependencies:

$$\begin{aligned} F = \{ABD &\to CE,\\ BCD &\to E,\\ B &\to ACDE,\\ A &\to B,\\ CD &\to AE\} \end{aligned}$$

Find and list all candidate keys of R. **Explain your answer.**

Exercise 8 — 1 Point

The original description of relational algebra also contains a division operator. The division $R \div S$ contains those attributes of R, that appear in **all combinations** of attributes from S. Consider the following example:

R

student	lecture
X	DB1
X	DB2
X	ADB
Y	DB1
Y	HCI
Z	DB1
Z	DB2

S

lecture
DB1
DB2

R÷S

student
X
Z

X and Z appear in R as a pair with all tuples from S, i.e., (X, DB1), (X, DB2), (Z, DB1) und (Z, DB2). Hence, X and Z are in the result. For Y, the pair (Y, DB2) is missing from R. Hence, Y is not in the result.

Show that the relational division $R \div S$ can be expressed using the **elementary operators** for this example.

Hint: Only the operators π, $\times$, and $-$ are required.

Hint: First, find an expression that contains all students (from R) and lectures (from S) that **do not** appear in R, i.e., express the following relation:

T

student	lecture
Y	DB2

Exercise 9 — 1 Point

Consider relation $R[A, B, C, D, E]$ with the following functional dependencies:

$$\begin{aligned} F = \{CDE &\rightarrow A, \\ E &\rightarrow ACD, \\ B &\rightarrow ACE, \\ BC &\rightarrow AE, \\ A &\rightarrow D\} \end{aligned}$$

What is the highest normal form satisfied by R?