Department of Computer Science

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PARIS LODRON UNIVERSITÄT SALZBURG

Databases I
Summer Semester 2024

Exam
24.07.2024

Name: _____ **Student ID:** _____

Hints

- Check whether you received all pages of the exam (12 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 _____

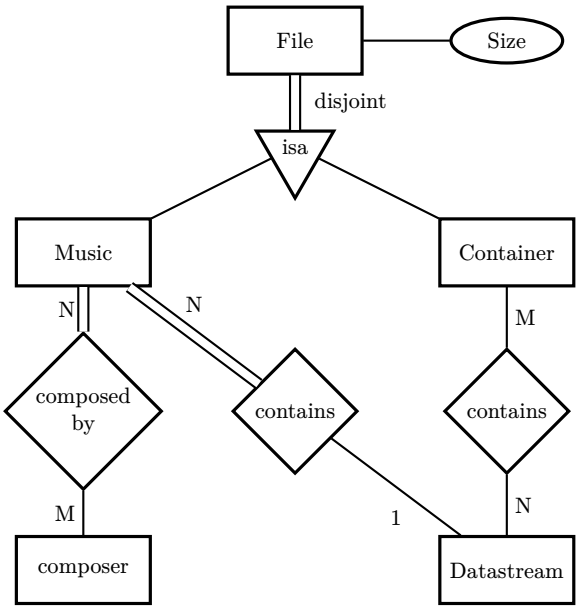
Grading

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 are files which are neither music nor containers. ☐
2. There are containers which contain no datastream. ☐
3. Music and containers can contain the same datastream. ☐
4. Composers can compose more than one piece of music. ☐
5. A datastream belongs to exactly one piece of music. ☐
6. A composer must compose at least one piece of music. ☐
7. A music file has the attribute size. ☐
8. Music must contain a datastream. ☐

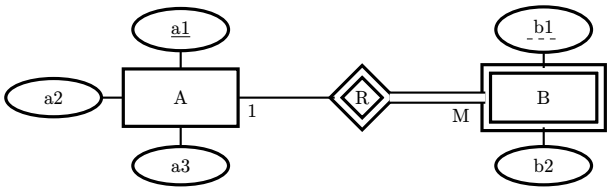
Exercise 2 — 1 Point

Draw an **ER-diagram** which satisfies the following requirements:

1. An animal has a unique ID and a name.
2. An animal can either be a cat, a mouse, or a dog.
3. A cat has a breed.
4. A dog has a color.
5. A cat must eat one or more mice.
6. A mouse can be eaten by exactly one cat.
7. A person has a unique SSN, a name, and a date of birth.
8. A dog can play with one or more people.
9. A person can play with one or more dogs.

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 (0.6 Points)

Foreign Key Constraints (0.4 Points)

This schema is used for the following exercises

Relational schema

Superhero(hero_name, firstname, lastname, birthplace)

Mission(mission_id, description, priority, time)

City(stadt_name, state, population)

MissionAssignment(mission_id, hero_name, city_name)

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**:

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

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:
The first- and lastname of all superheroes born in US.

Exercise 5 — 1 Point

Formulate the following query using **SQL**. Pay attention to syntactic correctness.

List all hero names that contain the substring "man" or are born in "Manhattan".

Exercise 6 — 1 Point

Formulate the following query using **SQL**. Pay attention to syntactic correctness.

Without duplicates, list each mission's ID and its corresponding city, sorted by ID (descending). (**0.4P**)

For each state, output the number of different missions per state. The previous query might be useful as a sub-query. (**0.6P**)

Exercise 7 — 1 Point

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

$$\begin{aligned} F = \{ & D \to CDE, \\ & E \to D, \\ & CEF \to EF, \\ & E \to ACDF, \\ & DF \to ACE\} \end{aligned}$$

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

Exercise 8 — 1 Point

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

$$\begin{aligned} F = \{ACDE &\rightarrow B,\\ D &\rightarrow AC,\\ AB &\rightarrow CE,\\ AD &\rightarrow ABE\} \end{aligned}$$

Compute the canonical cover F_C of F in the following four steps. Show your work for every step.

1. Left reduction.

2. Right reduction.

3. Remove empty sets.

4. Union.

Exercise 9 — 1 Point

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

$$F = \{A \to BCD,\\ BC \to DE,\\ B \to D\}$$

Prove that AG is a superkey using Armstrong's axioms. That is, show that $AG \to ABCDEG$ can be derived.

Hint: The Armstrong axioms are given by:

- Reflexivity: $Y \subseteq X \vDash X \to Y$
- Augmentation: $X \to Y \vDash XZ \to YZ$
- Transitivity: $X \to Y, Y \to Z \vDash X \to Z$

You may use the additional inference rules:

- Decomposition: $X \to YZ \vDash X \to Y, X \to Z$
- Union: $X \to Y, X \to Z \vDash X \to YZ$
- Pseudotransitivity: $X \to Y, WY \to Z \vDash WX \to Z$