UNIVERSITY OF GOTHENBURG

CHALMERS
UNIVERSITY OF TECHNOLOGY

Exam

DIT032 / DAT335 – Data Management
Take-Home Edition

Friday, August 21st, 2020 14:00 - 19:00 (+ 30 minute grace period)

Examiner:
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Allowed Aides:
You may refer to all class material during the exam.
This is still an individual exam, communicating with people other than teachers during the exam period – independently of whether that's in-person or via Slack / Facebook / SMS / etc. – is strictly forbidden.

Results:
Exam results will be made available no later than in 15 working days through Ladok.

Grade Limits:
For GU students: 0 – 49 pts: U, 50 – 84 pts: G, 85+ pts: VG
For Chalmers students: 0 – 49 pts: U, 50 – 69 pts: 3, 70 – 84 pts: 4, 85+ pts: 5

Review:
Exam reviews will be handled on demand via Zoom.

Task 1 – Theory and Understanding (17 pts)

Each of the following questions requires an approximately two to four paragraphs long answer **in your own words**. Use figures or sketches if appropriate. Read the questions carefully, and make sure to answer the question that is asked.

Q1.1: Compare relational algebra and SQL. What key concepts are different in the two? Also discuss how SQL databases such as Postgres practically make use of relational algebra concepts. *(5 pts)*

Q1.2: Assume you have a large sharded MongoDB database containing millions of documents with a structure as in the example below (customer documents and movie streams they have watched). Describe (in exact words, pseudocode, or Javascript code) a Map/Reduce program that you can run against the database to collect a list of movies and their total stream durations (added up across all customers). Note that the same customer can watch a movie multiple times. *(7 pts)*

```
{
  _id : ObjectId('1234567890ABCDEF12345678'),
  customer: '123456',
  streams: [
    { movie: 'Scary Movie', stream_duration: 12 },
    { movie: 'Passengers', stream_duration: 91 },
    { movie: 'Scary Movie', stream_duration: 66 },
  ]
}
```

Q1.3: Assume a database isolaton level of `READ UNCOMMITTED`. Provide and discuss an example database interaction that suffers from a dirty read. Develop your own example – existing examples from the lecture slides, book, or the Internet do not count. *(5 pts)*

Task 2 – EER Diagrams (24 pts)

Consider the following excerpt of the domain description for the database of a streaming service. Model the described domain using an EER diagram with the notation we used in the course (find a cheat sheet in the appendix of your exam papers). Use the 1,N,M notation for describing cardinalities rather than the min-max notation. If *and only if* something is not specified, make a reasonable assumption and note it down in plain text.

Streaming Service Database:

At the heart of the system are users. For users we need to save an unique username and their watching preferences. There are two types of users. Free users have a quota (their account is disabled if they watch more than their quota in a month). Paying users have no quota, but we need to store their credit card information, which consists of an unique credit card number, an address, and a validity date. Free user accounts can be linked to paying accounts, which increases their quota. Every free account can be linked to at most one paying account, and every paying account can have a maximum of 3 free accounts linked to it.

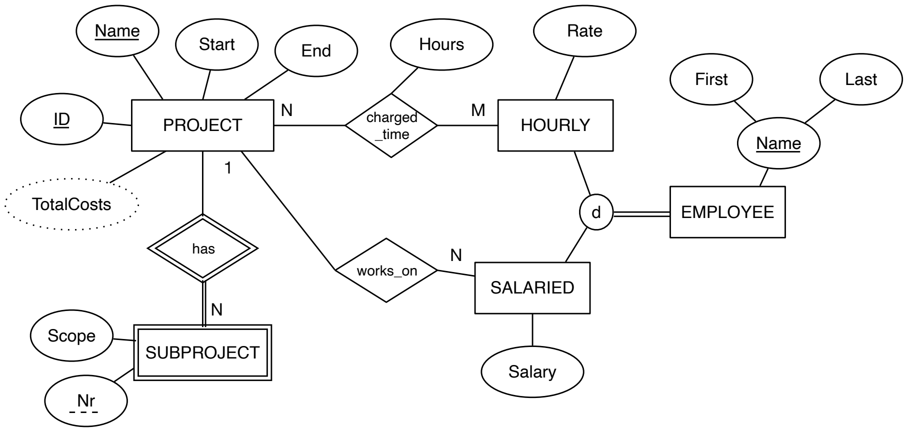
Users stream content, i.e., movies or series episodes. Whenever a user streams content, we need to save the actual duration of how long they watched. For simplicity, you can assume that users are unable to stream the same content multiple times, but of course the same content can be streamed to multiple users, and a user can stream multiple different content items. For all types of content, we need to save the genre, the length, and the release date. Further, we need to save the actual movie data. For movies, we also need to store an unique title. Episodes are collected in series. For each series, we need to store its unique title, when it aired for the first time. A series can have multiple episodes, each of which has a title (which is optional and does not have to be unique). Episodes are identified through an episode key consisting of the combination of season and episode number (e.g., Season 1 - Episode 5). Episode keys are only unique in combination with the title of the series.

For each user, the system generates exactly one unique personalized recommendation list. Each list is identified through an unique id, and contains 10 items, typically (but not necessarily) a combination of movies and series. Movies and series can be contained in multiple recommendation lists, but don't have to be in any.

Finally, we need to keep track of actors in our database. We need to store the (unique) names of actors, but we need to keep track of which episodes or movies they appeared in and which role they played. An actor has to have appeared in at least one episode or movie, but they could have been in many. Most streaming content has many actors appearing in them, but some also make due without any actors (e.g., animation movies). As a special feature, paying users can follow any number of actors and get informed whenever new content featuring them is released. Evidently, the same actor can be followed by many paying users.

Task 3 – Mapping Inheritance (10 pts)

Consider the EER model below. Construct a relational model that represents this domain. Select primary keys and introduce foreign keys as necessary. Use the notation that we used in the course to indicate relations, attributes, primary keys, and foreign keys (see Task 4 for an example of the required notation).



Task 4 – Relational Algebra (20 pts)

Relational Model:
USER(<u>username</u>, quota, reg_date)

MOVIE(<u>title</u>, genre, duration)

STREAM(<u>id</u>, user, movie, date, completion)
user $\rightarrow$ USER.username
movie $\rightarrow$ MOVIE.title

ACTOR(<u>name</u>, <u>movie</u>)
movie $\rightarrow$ MOVIE.title

(STREAM.completion is a percentage – e.g., 0.75 represents 75% – indicating how much of the movie the user streamed before stopping the stream)

Given this relational model, write relational algebra statements that exactly represent the following queries. Use the mathematical notation from the course (for the correct notation you can again refer to the appendix).

Queries:

Q4.1: Return all unique registration dates.

Q4.2: Report the length of each stream. The length is defined as the percent the stream finished the movie (completion) multiplied by the duration of the movie.

Q4.3: Return a list of usernames along with a count how many movies they have streamed to completion (i.e., where percent is equal to 1). You do not have to consider the case of a user streaming the same movie multiple times.

Q4.4: Return all titles of movies that have either been streamed by the user "philipp" or which feature the actress "Jennifer Lawrence".

Task 5 – SQL (20 pts)

Given the same relational model as for Task 4, write the following SQL queries.

Queries:

Q5.1: Provide an alphabetically sorted list of all actors that appeared in "Scary Movie".

Q5.2: Provide a list of all users that have exceeded their quota since the start of the month. The quota counts as exceeded when the sum of the lengths of all streams of this user is larger than their quota. The length of a stream is again defined as the percent the stream finished the movie (completion) multiplied by the duration of the movie.

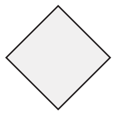
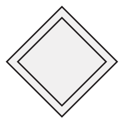
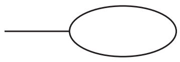
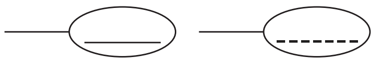
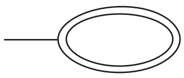
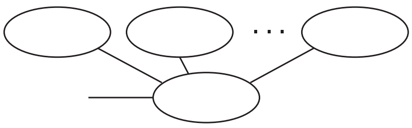
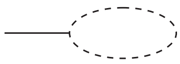
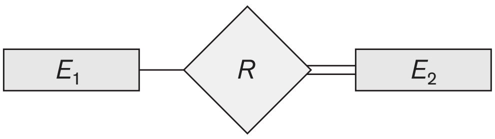
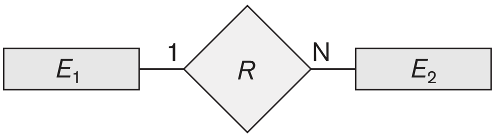
Q5.3: Provide a list of all users and the unique titles of the movies they have streamed. If a user has not yet streamed any movie, they should still be contained in the list (with a NULL value for the movie title).

Q5.4: Find all actors that appeared in more movies than "John Carradine".

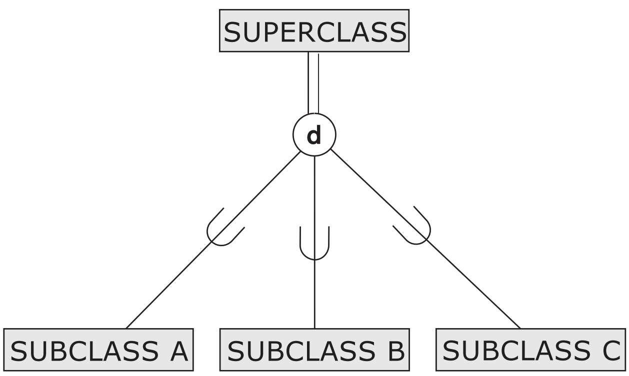
Task 6 – XML and JSON (9 pts)

Refer back to the domain model used in Task 3 (projects and employees). Write an example XML document representing one example project with at least two subprojects and 3 salaried employees working on this project. All attributes of these entity types should be used at least once. Make use of all of the following: subelements, attributes, and text nodes. Assume arbitrary data as attribute values. Take care that your file is well-formed XML.

Appendix: Notation Guidelines for EER and RA

Symbol	**Meaning**
	Entity
	Weak Entity
	Relationship
	Indentifying Relationship
	Attribute
	Key Attribute / Dashed Underline for Partial Key
	Multivalued Attribute
	Composite Attribute
	Derived Attribute
	Total Participation of E_2 in R
	Cardinality Ratio 1: N for E_1 : E_2 in R

Total Disjoint Specialization



Partial Overlapping Specialization

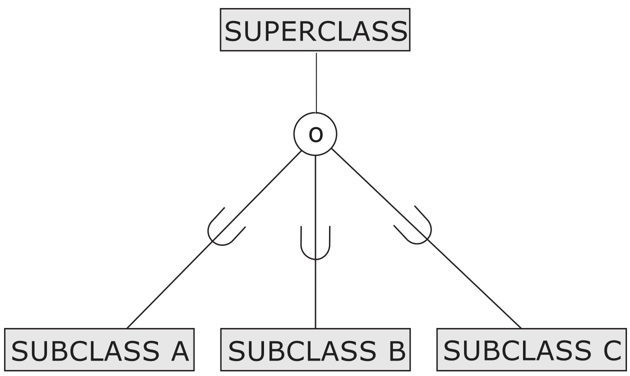


Table 8.1 Operations of Relational Algebra

OPERATION	PURPOSE	NOTATION
SELECT	Selects all tuples that satisfy the selection condition from a relation R.	$\sigma_{<\text{selection condition}>}(R)$
PROJECT	Produces a new relation with only some of the attributes of R, and removes duplicate tuples.	$\pi_{<\text{attribute list}>}(R)$
THETA JOIN	Produces all combinations of tuples from R_1 and R_2 that satisfy the join condition.	$R_1 \bowtie_{<\text{join condition}>} R_2$
EQUIJOIN	Produces all the combinations of tuples from R_1 and R_2 that satisfy a join condition with only equality comparisons.	$R_1 \bowtie_{<\text{join condition}>} R_2$, OR $R_1 \bowtie_{(<\text{join attributes 1}>),\ (<\text{join attributes 2}>)} R_2$
NATURAL JOIN	Same as EQUIJOIN except that the join attributes of R_2 are not included in the resulting relation; if the join attributes have the same names, they do not have to be specified at all.	$R_1 *_{<\text{join condition}>} R_2$, OR $R_1 *_{(<\text{join attributes 1}>),\ (<\text{join attributes 2}>)} R_2$ OR $R_1 * R_2$
UNION	Produces a relation that includes all the tuples in R_1 or R_2 or both R_1 and R_2; R_1 and R_2 must be union compatible.	$R_1 \cup R_2$
INTERSECTION	Produces a relation that includes all the tuples in both R_1 and R_2; R_1 and R_2 must be union compatible.	$R_1 \cap R_2$
DIFFERENCE	Produces a relation that includes all the tuples in R_1 that are not in R_2; R_1 and R_2 must be union compatible.	$R_1 - R_2$
CARTESIAN PRODUCT	Produces a relation that has the attributes of R_1 and R_2 and includes as tuples all possible combinations of tuples from R_1 and R_2.	$R_1 \times R_2$
DIVISION	Produces a relation $R(X)$ that includes all tuples $t[X]$ in $R_1(Z)$ that appear in R_1 in combination with every tuple from $R_2(Y)$, where $Z = X \cup Y$.	$R_1(Z) \div R_2(Y)$

<grouping>$\mathscr{F}$<functions>(R)

whereas <functions> is a list of

[MIN|MAX|AVERAGE|SUM|COUNT] <attribute>