Database Systems – 4th Semester 2024
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Exercise Sheet: Relational Algebra

1 Relational Algebra

Given the following relations:

animals						
animalID	nickname	species	gender	zooID	father	mother
1	Tally	giraffe	female	1	3	2
2	Kathy	giraffe	female	2	–	–
3	Billy	giraffe	male	3	–	–
4	Stan	ape	male	1	5	–
5	Pam	ape	male	2	–	–
6	Uhu	owl	male	2	9	8
7	Jahoo	owl	male	1	10	11
8	Boo	owl	female	1	10	11
9	Wohoo	owl	male	2	–	–
10	Huhuu	owl	male	1	–	–
11	Eule	owl	female	1	–	–

zoos			
zooID	name	city	country
1	Zoo Frankfurt	Frankfurt	Germany
2	Tiergarten Schönbrunn	Vienna	Austria
3	Aalborg Zoo	Aalborg	Denmark

Please determine the results for the following relational algebra expressions:

1. $(\pi_{species,zooID} \quad (animals)) \quad \div \quad (\pi_{zooID} \quad (\sigma_{country='Germany'} \quad (zoos)))$
2. $\pi_{T1.nickname} \quad (\sigma_{T1.animalID=T2.father} \quad \vee \quad {}_{T1.animalID=T2.mother}($
   $(\rho_{T1}(animals)) \quad \bowtie_{T1.zooID=T2.zooID} \quad (\rho_{T2}(animals))))$

2 Result cardinality

Given two relations: relation R has m tuples, relation S has n tuples with $n, m > 1$. Please state the minimum and maximum number of result tuples (result cardinality) for the following expressions.

1. $\sigma_p(R)$ with p representing an arbitrary (valid) predicate
2. $\pi_A(R)$ with A representing a valid arbitrary non-empty subset of attributes ($A \subseteq \mathcal{R}$)
3. $R \bowtie_\Theta S$ with Θ representing an arbitrary valid theta join predicate
4. $R - (R - S)$ where R and S having the same schema

3 Company Database

Consider the following relations, where the primary keys are underlined:

`employee(`<u>`person_name`</u>`, street, city)`
`works(`<u>`person_name`</u> $\rightarrow$ `employee, company_name` $\rightarrow$ `company, salary)`
`company(`<u>`company_name`</u>`, city)`
`manages(`<u>`person_name`</u> $\rightarrow$ `employee, manager_name` $\rightarrow$ `employee)`

3.1 (Easy) Give an expression in relational algebra for each of the following queries:

(a) Find the names of all employees who live in the city "Miami".

(b) Find the names of all employees whose salary is greater than $100,000.

(c) Find the names of all employees who live in "Miami" and whose salary is greater than $100,000.

3.2 Give an expression in relational algebra for each of the following queries:

(a) Find the names of all employees who work for "First Bank Corporation".

(b) Find the names and cities of residence of all employees who work for "First Bank Corporation".

(c) Find the names, street addresses, and cities of residence of all employees who work for "First Bank Corporation" and earn more than $10,000.

(d) Find the names of all employees who live in the same city as the company they work for.

(e) Assume companies may be located in several cities (assume relation company is defined as `company(`<u>`company_name, city`</u>`)` for this question). Find all companies located in **every** city in which "Small Bank Corporation" is located.

3.3 Give an expression in relational algebra for each of the following queries:

(a) Find the names of all employees who live in the same city and on the same street as do their managers.

(b) Find the names of all employees who do not work for "First Bank Corporation". Consider the following two cases (1) all people appearing in the database work for exactly one company and (2) people may appear in relation *employee* although they do not appear in relation *works*.

(c) Find the names of **all** employees who earn more than **every** employee of "Small Bank Corporation".

3.4 Give an expression in relational algebra for each of the following queries:

(a) Find the number of employees for each company.

(b) Find the companies whose employees earn a higher salary on average, than the average salary at First Bank Corporation.

4 Relational Division

Consider the formal definition of the relational division (alternative expression in relational algebra using only fundamental operations and producing the same result), try to understand why the alternative expression is correct, and describe the steps with your own words.