Database Management Systems

(COP 5725)

Spring 2020

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Homework 2

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Pledge (Must be signed according to UF Honor Code)

On my honor, I have neither given nor received unauthorized aid in doing this assignment.

Xiao Hu.

Signature

For scoring use only:

	Maximum	Received
Exercise 1	25	
Exercise 2	25	
Exercise 3	22	
Exercise 4	28	
Total	100	

Exercise 1 (Relational Algebra) [25 points]

Consider the following relations. The primary keys are underlined. All attributes are of type string if not indicated otherwise.

- Student (<u>s_ID</u>, s_name, s_degree: integer, advisorID, d_ID)
- Lecture (<u>l_ID</u>, l_name, l_degree: integer, p_ID, d_ID)
- Register (<u>s_ID</u>, <u>l_ID</u>, score: integer, Semester)
- Professor (<u>p_ID</u>, p_name, d_ID)
- Department (<u>d_ID</u>, d_name, address)

1. [5 points] Find the names of professors who have taught in every semester.
2. [5 points] List the names of lectures that the CISE department offers but that are taught by a professor whose department is not CISE.
3. [5 points] Find the names of students who got the highest score in the lecture ‘Databases’.
4. [5 points] Find the names of students who have registered every lecture of the CISE department.
5. [5 points] Find the names of students who got more than 90 in the ‘DB’ lecture and less than 70 in the ‘Algorithm’ lecture.

1. $\rho_{R_1}(\Pi_{l\_ID, Semester}(Register))$

$\rho_{R_2}(\Pi_{p\_ID}(\Pi_{p\_ID, semester}(R_1 \bowtie Lecture) \div \Pi_{semester}(Register)))$

$\Pi_{p\_name}(R_2 \bowtie Professor)$

2. $\rho_{R_1}(\Pi_{l\_name, p\_ID, d\_ID}(Lecture) \bowtie \Pi_{d\_ID}(\sigma_{d\_name='CISE'}(Department)))$

$\rho_{R_2}(\Pi_{p\_ID}(\Pi_{d\_ID}(\sigma_{d\_name='CISE'}(Department)) \bowtie Professor))$

$\Pi_{l\_name}((\Pi_{p\_ID}(R_1) - R_2) \bowtie Professor)$

3.

$$\rho_{R_1}\left(\Pi_{L\_ID}\left(\sigma_{L\_name='Databases'}(Lecture)\right)\right)$$

$$\rho_{R_2}\left(\Pi_{S\_ID,\ score}\left(R_1 \bowtie Register\right)\right)$$

$$\rho_{R_3}(R_2)$$

$$\rho_{R_4}\left(R_2 - \Pi_{R_2}\left(\sigma_{R_2.score < R_3.score}(R_2 \times R_3)\right)\right)$$

$$\Pi_{S\_name}\left(\Pi_{S\_ID}(R_4) \bowtie Student\right)$$

4.

$$\rho_{R_1}\left(\Pi_{L\_ID}\left(\sigma_{d\_name='CISE'}(Department) \bowtie Lecture\right)\right)$$

$$\Pi_{S\_name}\left(\Pi_{S\_ID}\left(\Pi_{S\_ID,L\_ID}(Register) \div R_1\right) \bowtie Student\right)$$

5.

$$\rho_{R_1}\left(\Pi_{L\_ID}\left(\sigma_{L\_name='DB'}(Lecture)\right) \bowtie Register\right)$$

$$\rho_{R_2}\left(\Pi_{L\_ID}\left(\sigma_{L\_name='Algorithm'}(Lecture)\right) \bowtie Register\right)$$

$$\rho_{R_3}\left(\Pi_{S\_ID}\left(\sigma_{score>90}(R_1)\right)\right)$$

$$\rho_{R_4}\left(\Pi_{S\_ID}\left(\sigma_{score<70}(R_2)\right)\right)$$

$$\Pi_{S\_name}\left((R_3 \cap R_4) \bowtie Student\right)$$

Exercise 2 (Relational Algebra) [25 points]

Consider the following relations for an online Cinema Booking system. The primary keys are underlined. All attributes are of type string if not indicated otherwise.

- Theaters(<u>tID</u>, name, location)
- Auditoriums(<u>tID</u>, <u>aID</u>, movie title, price: integer, number of seats: integer)
- Book(<u>tID</u>, <u>aID</u>, <u>cID</u>, seat number, date)
- Customers(<u>cID</u>, name, address)

A theater usually has several auditoriums. Assume that only the movies that are currently played on auditoriums of theaters are stored.

1. [4 points] Find the names of customers who have watched movies at every theater in Gainesville.
2. [3 points] Find the names of customers who never booked.
3. [6 points] Find the names of customers who booked the movie titled 'Parasite' more than once.
4. [4 points] Find the name of the theater that has the biggest (in terms of the number of seats) auditorium.
5. [4 points] Find the names of customers who booked 'Parasite' and 'End game'.
6. [4 points] Find the names of movies that are playing at the theaters where the movie 'End game' is on (exclude 'End game' in your answer).

1. $\rho_{R_1}(\Pi_{tID}(\sigma_{location='Gainesville'}(Theaters)))$

$\Pi_{name}((\Pi_{tID,cID}(Customers \bowtie Book) \div R_1) \bowtie Customers)$

2. $\Pi_{name}((\Pi_{cID}(Customers) - \Pi_{cID}(Book)) \bowtie Customers)$

3. $\rho_{R_1}(\Pi_{tID,aID,cID}(\Pi_{tID,aID}(\sigma_{movie\ title='Parasite'}(Auditoriums)) \bowtie Book))$

$\rho_{R_2}(R_1)$

$$\rho_{R_3}\left(\pi_{R_1.cID}\left(\sigma_{R_1.tID=R_2.tID \wedge R_1.aID \neq R_2.aID \wedge R_1.cID=R_2.cID}\ (R_1 \times R_2)\right)\right)$$

$$\rho_{R_4}\left(\pi_{R_1.cID}\left(\sigma_{R_1.tID \neq R_2.tID \wedge R_1.cID=R_2.cID}\ (R_1 \times R_2)\right)\right)$$

$$\pi_{name}(R_3 \bowtie Customers \bowtie R_4)$$

4.

$$\rho_{R_1}(Auditoriums)$$

$$\rho_{R_2}(R_1)$$

$$\rho_{R_3}\left(R_1 - \pi_{R_1}\left(\sigma_{R_1.number\ of\ seats < R_2.number\ of\ seats}\ (R_1 \times R_2)\right)\right)$$

$$\pi_{name}(\pi_{tID}(R_3) \bowtie Theaters)$$

5.

$$\rho_{R_1}\left(\pi_{tID,aID}\left(\sigma_{movie\ title='Parasite'}(Auditoriums)\right)\right)$$

$$\rho_{R_2}\left(\pi_{tID,aID}\left(\sigma_{movie\ title='End\ game'}(Auditoriums)\right)\right)$$

$$\rho_{R_3}\left(\pi_{cID}\ (R_1 \bowtie Book)\right) \qquad \rho_{R_4}\left(\pi_{cID}(R_2 \bowtie Book)\right)$$

$$R_3 \cap R_4.$$

6.

$$\rho_{R_1}\left(\pi_{tID}\left(\sigma_{movie\ title='End\ game'}(Auditoriums)\right)\right)$$

$$\rho_{R_2}\left(\pi_{movie\ title}\ (R_1 \bowtie Auditoriums.)\right)$$

$$\sigma_{movie\ title \neq 'End\ game'}(R_2)$$

Exercise 3 (Relational Algebra) [22 points]

Consider the following relations. The primary keys are underlined. All attributes are of type string if not indicated otherwise.

- Suppliers (<u>sID</u>, sname, address)
- Parts (<u>pID</u>, pname, color)
- Catalog (<u>sID</u>, <u>pID</u>, cost: integer)

1. [6 points] Find the names of the most expensive parts supplied by supplier named 'NESCS'.

2. [4 points] Find the names of the parts supplied by at least two different suppliers.

3. [4 points] Find the ids of suppliers who supply every red part or supply every green part.

4. [4 points] Find pairs of supplier ids such that the supplier with the first sID charges more for the same part than the supplier with the second sID.

5. [4 points] Find the names of suppliers who supply only red parts.

1.

$$\rho_{R_1}(\pi_{pID,\, cost}(\sigma_{sname='NESCS'}(Suppliers) \bowtie Catalog))$$

$$\rho_{R_2}(R_1)$$

$$\rho_{R_3}(R_1 - \pi_{R_1}(\sigma_{R_1.cost<R_2.cost}(R_1 \times R_2)))$$

$$\pi_{pname}(R_3 \bowtie Parts)$$

2.

$$\rho_{R_1}(Catalog)$$

$$\rho_{R_2}(R_1)$$

$$\rho_{R_3}(\pi_{pID}(\pi_{R_1}(\sigma_{R_1.pID=R_2.pID \wedge R_1.sID \neq R_2.sID}(R_1 \times R_2))))$$

$$\pi_{pname}(R_3 \bowtie Parts)$$

3.

$$\rho_{R_1}(\Pi_{pID}(\sigma_{color='red'}(Parts)))$$

$$\rho_{R_2}(\Pi_{pID}(\sigma_{color='green'}(Parts)))$$

$$\Pi_{sID}(\Pi_{sID,pID}(Catalog) \div R_1) \cup \Pi_{sID}(\Pi_{sID,pID}(Catalog) \div R_2)$$

4.

$$\rho_{R_1}(Catalog)$$

$$\rho_{R_2}(R_1)$$

$$\Pi_{R_1.sID,R_2.sID}(\sigma_{R_1.pID=R_2.pID \wedge R_1.cost > R_2.cost}(R_1 \times R_2))$$

5.

$$\rho_{R_1}(\Pi_{pID}(\sigma_{color='red'}(parts)))$$

$$\rho_{R_2}(\Pi_{sID,pID}(Catalog))$$

$$\rho_{R_3}(\Pi_{sID}((R_2 - (\Pi_{pID}(R_2) \cap R_1)) \bowtie R_2))$$

$$\Pi_{sID}(R_2) - R_3$$

Exercise 4 (Relational Algebra) [28 points]

The following questions let you think deeper about the concepts of the Relational Algebra.

1. [6 points] Let $\mathbb{R}$ be the schema of a relation R, and let $A_1, A_2, \ldots, A_n \subseteq \mathbb{R}$. Is the term $\pi_{A_1}(\pi_{A_2}(\ldots(\pi_{A_n}(R))\ldots)) = \pi_{A_1}(R)$ correct, in general? If yes, argue why. If not, argue why not. If your answer is no, are there any restrictions that could make the statement true? If so, what are these restrictions in mathematical notation?

2. [6 points] Let $\mathbb{R}$ be the schema of a relation R, and let $A \subseteq \mathbb{R}$. What is the condition in mathematical notation such that $\pi_A(\sigma_F(R)) = \sigma_F(\pi_A(R))$ holds where F is assumed to be a correct predicate on R?

3. [16 points] Let $R(A, B)$ be a relation with $r > 0$ tuples, and let $S(B, C)$ be a relation with $s > 0$ tuples. We assume that A, B, and C have the *same data type*. For each of the following Relational Algebra expressions, in terms of r and s, determine the *minimum* and *maximum number of tuples* that the result relation can have. In other words, we are interested in the number of tuples the following Relational Algebra expressions can have *at least* and *at most*. The numbers have to be given by using the two variables r and s. Please note that you have to give precise explanations for your answers.

   a. [4 points] $R \cup \rho_{T(A,B)}(S)$

   b. [3 points] $(R \bowtie R) \bowtie R$

   c. [4 points] $\pi_{A,\,C}(R \bowtie S)$

   d. [5 points] $\sigma_{A=C}(R \bowtie S)$

1. not correct. Because of $A_1, A_2, \ldots A_n$ could be disjointed, the $\pi_{A_n}(R)$ can not have attribute A_1 or $A_2 \ldots A_{n-1}$,

if $A_1 \subseteq A_2 \subseteq \ldots \subseteq A_n \subseteq R$ can make the statement true.

2. if $F \subseteq A$, then the mathematical notation

must be true, because if F contains attributes not belong to A, $\sigma_F(\pi_A(R))$ will ignore these attributs not belong to A.

3.

a. rename the $S(B,C)$ to $T(A,B)$ and the $R(A,B) \cup T(A,B)$

$R=S$ / $R \subset T$ / $T \subset R$: $\max(r,s)$

when $R \cap T = \emptyset$: $r+s$

So the minimum number is $\max(r,s)$.

and the maximum number is $r+s$

b. $(R \bowtie R) \bowtie R = R$

So the minimum number is r.

and the maximum number is r

c. $R(A,B)$ $S(B,C)$

$R \bowtie S \Rightarrow (A,B,C)$

$\pi_{A,B}(R \bowtie S) \Rightarrow (A,B)$

if $\pi_B(R) \cap \pi_B(S) = \emptyset$ result is 0

if $\pi_B(R) \cap \pi_B(S) = \pi_B(R)$ result is $r \times s$

so the minimum number is 0

and the maximum number is $r \times s$

d.

$R \bowtie S \Rightarrow (A, B, C)$

if $\pi_B(R) \cap \pi_B(S) = \emptyset$ result is 0

if $\pi_B(R) \cap \pi_B(S) \Rightarrow \min(\pi_B(R), \pi_B(S))$

and the number of attribute A or C are equal, so the result is $\min(r, s)$

so the minimum number is 0

and the maximum number is $\min(r, s)$