GATE 2025 DBMS

June 2024

Relational Algebra & Tuple Relational Calculus (TRC)

Questions

Question 1. *Given two relations R1 and R2, where R1 contains N1 tuples, R2 contains N2 tuples, and N2 > N1 > 0, give the minimum and maximum possible sizes (in tuples) for the resulting relation produced by each of the following relational algebra expressions. In each case, state any assumptions about the schemas for R1 and R2 needed to make the expression meaningful:*

1. $R1 \cup R2$

2. $R1 \cap R2$

3. $R1 - R2$

4. $R1 \times R2$

5. $\sigma_{a=5}(R1)$

6. $\pi_a(R1)$

7. $R1/R2$

Question 2. *Consider the following schema:*

- **Suppliers**(*sid: integer, sname: string, address: string*)

- **Parts**(*pid: integer, pname: string, color: string*)

- **Catalog**(*sid: integer, pid: integer, cost: real*)

*The key fields are underlined, and the domain of each field is listed after the field name. Thus sid is the key for **Suppliers**, pid is the key for **Parts**, and sid and pid together form the key for **Catalog**. The **Catalog** relation lists the prices charged for parts by suppliers. Write the following queries in relational algebra and tuple relational calculus:*

1. *Find the names of suppliers who supply some red part.*

2. *Find the sids of suppliers who supply some red or green part.*

3. *Find the sids of suppliers who supply some red part or are at 221 Packer Ave.*

4. *Find the sids of suppliers who supply some red part and some green part.*

5. *Find the sids of suppliers who supply every part.*

6. *Find the sids of suppliers who supply every red part.*

7. *Find the sids of suppliers who supply every red or green part.*

8. *Find the sids of suppliers who supply every red part or supply every green part.*

9. *Find pairs of sids such that the supplier with the first sid charges more for some part than the supplier with the second sid.*

10. *Find the pids of parts that are supplied by at least two different suppliers.*

11. *Find the pids of the most expensive parts supplied by suppliers named Yosemite Sham.*

12. *Find the pids of parts supplied by every supplier at less than $200. (If any supplier either does not supply the part or charges more than $200 for it, the part is not selected.)*

Question 3. *Consider the Supplier-Parts-Catalog schema from the previous question. State what the following queries compute:*

1. $\pi_{sname}(\pi_{sid}(\sigma_{color='red'}(Parts)) \bowtie (\sigma_{cost<100}(Catalog)) \bowtie Suppliers)$

2. $\pi_{sname}(\pi_{sid}((\sigma_{color='red'}(Parts)) \bowtie (\sigma_{cost<100}(Catalog)) \bowtie Suppliers))$

3. $(\pi_{sname}((\sigma_{color='red'}(Parts)) \bowtie (\sigma_{cost<100}(Catalog)) \bowtie Suppliers)) \cap (\pi_{sname}((\sigma_{color='green'}(Parts)) \bowtie (\sigma_{cost<100}(Catalog)) \bowtie Suppliers))$

4. $(\pi_{sid}((\sigma_{color='red'}(Parts)) \bowtie (\sigma_{cost<100}(Catalog)) \bowtie Suppliers)) \cap (\pi_{sid}((\sigma_{color='green'}(Parts)) \bowtie (\sigma_{cost<100}(Catalog)) \bowtie Suppliers))$

5. $\pi_{sname}((\pi_{sid,sname}((\sigma_{color='red'}(Parts)) \bowtie (\sigma_{cost<100}(Catalog)) \bowtie Suppliers)) \cap (\pi_{sid,sname}((\sigma_{color='green'}(Parts)) \bowtie (\sigma_{cost<100}(Catalog)) \bowtie Suppliers)))$

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Question 4. *Given below is a small DB schema covering student enrollments in university courses, with primary keys underlined and foreign keys listed to the right. Below that are four questions for each type of calculus (two of the questions are shared). Try to answer all of the questions for each language before consulting any of the answers on the second page.*

Schema:

- **Student:** <u>ID</u>, Name, Major

- **Course:** Dept, <u>Num</u>, Title

- **Dept:** <u>Abbrev</u>, Name, Office

- **Enroll:** SID, Dept, Num, Date

Major is a FK to Dept in Course
Dept is a FK to Abbrev in Dept
SID is a FK to ID in Student
Dept-Num is a FK to Dept-Num in Course

Tuple Relational Calculus

1. *Express the following English queries in TRC:*

   (a) *What are the department abbreviations and titles of all courses numbered 101?*

   (b) *What are the IDs of the MATH students taking "Discrete Structures?"*

2. *For each of these TRC queries, what is the corresponding query in conversational English?*

   (a) $\{s.Name, s.ID \mid Student(s) \; s.Major = 'CSC'\}$

   (b) $\{e.Date \mid Enroll(e) \; (\exists c)(Course(c) \; e.Dept = c.Dept \; e.Num = c.Num \; c.Title = 'Database Design')\}$