Relational Algebra Exercises

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1 Database system concepts chapter 6

1.1 Exercise

Find the name of all instructors in the "Physics" department:

$$\Pi_{\text{name}}\left(\sigma_{\text{dept\_name = "Physics"}}(\text{instructor})\right)$$

1.2 Exercise

Consider a query to find the set of all courses taught in the Fall 2009 semester, the Spring 2010 semester, or both.

$$\Pi_{\text{course\_id}}\left(\sigma_{\text{ (year = 2009}\wedge\text{semester = "Fall")}\vee\text{(year = 2010}\wedge\text{semester = "Spring")}}(\text{section})\right)$$

Alternatively, we could use the set union as follows:

$$\Pi_{\text{course\_id}}\left(\sigma_{\text{year = 2009}\wedge\text{semester = "Fall"}}(\text{section})\right)$$
$$\bigcup$$
$$\Pi_{\text{course\_id}}\left(\sigma_{\text{year = 2010}\wedge\text{semester = "Spring"}}(\text{section})\right)$$

1.3 Exercise

Find all courses of Fall 2009 that were not in Spring 2010:

$$\Pi_{\text{course\_id}}\left(\sigma_{\text{year = 2009}\wedge\text{semester = "Fall"}}(\text{section})\right)$$
$$-$$
$$\Pi_{\text{course\_id}}\left(\sigma_{\text{year = 2010}\wedge\text{semester = "Spring"}}(\text{section})\right)$$

In this case, we use the we use the ser difference instead of the union

1.4 Exercise

Find the name of all instructors in the Physics department, along with all the courses they have taught.

$$\Pi_{\text{name, course\_id}}\left(\sigma_{\substack{\text{dept\_name = "Physics"} \\ \wedge \\ \text{instructor.id = teaches.id}}}(\text{instructor} \times \text{teaches})\right)$$

1.5 Exercise

Find the highest salary in the university.

$$\Pi_{\text{salary}}\,(\text{instructor})$$

$$-$$

$$\Pi_{i_1.\text{salary}}\,(\sigma_{i_1.\text{salary}<i_2.\text{salary}}\,(\rho_{i_1}(instructor) \times \rho_{i_2}(instructor)))$$

We first calculate the salaries that are not the maximum and then remove them from the total set. Hence, we are left with the highest salary in the university.

1.6 Exercise

Find the set of courses taught in both Fall 2009 and Spring 2010

$$\Pi_{\text{course\_id}}\,(\sigma_{\text{year} = 2009 \wedge \text{semester} = \text{"Fall"}}\,(\text{section}))$$

$$\bigcap$$

$$\Pi_{\text{course\_id}}\,(\sigma_{\text{year} = 2010 \wedge \text{semester} = \text{"Spring"}}\,(\text{section}))$$

Even though the intersection of sets is not a fundamental relational algebra operation, we can obtain it through the use of union and set difference operations as a result of DeMorgan's laws. The $\cap$ notation can be used to simplify this process.

1.7 Exercise

Find the name of all the instructors as well as all the courses they have thougt.

$$\Pi_{instructor\_ID, course\_ID}(\text{instructor} \bowtie \text{teaches})$$

Simpler way to solve a previous ecercise using the "natural join" operation.

1.8 Exercise

Find the names of all the structures in the Comp. Sci. department together with all the course titles of the courses they have tought.

$$\Pi_{\text{name, title}}\Big(\big(\sigma_{\text{dept\_name} = \text{"CompSci"}}\,(\text{instructor})\big) \bowtie \text{teaches} \bowtie \text{course}\Big)$$

2 Practice exercises by ChatGPT

2.1 Schema of reference

Following our previous theme, we shall consider the following schema:

- Student(SID, Name, Major)
- Course(CID, Title, Department)
- Enrolled(SID, CID, Grade)
- Professor(PID, Name, Department)
- Teaches(PID, CID)

2.2 Exercise

Find the names of students majoring in "Computer Science"

$$\Pi_{\text{nme}}\left(\sigma_{\text{major = "CompSci"}}(\text{student})\right)$$

2.3 Exercise

List the title of courses taught by professors from the "Mathematics" department.

$$\Pi_{\text{title}}\Big(\sigma_{\text{department = "Mathematics"}}(\text{professor}) \bowtie \text{teaches} \bowtie \text{course}\Big)$$

2.4 Exercise

Find the name of students who are enrolled in at least one course taught by "Dr. Smith".

$$A := \Pi_{\text{PID}}\left(\sigma_{\text{name = "Smith"}}(\text{professor})\right)$$

$$B := \Pi_{\text{CID}}\left(\sigma_{\text{PID}\in A}(\text{teaches})\right)$$

$$\Pi_{\text{name}}\left(\sigma_{\text{CID}\in B}(\text{Enrolled}) \bowtie \text{Student}\right)$$

We use the subquery notation to visually simplify the query, but this could be done in a single step. In this context, A represents Smith's ID (there could theoretically be several of them), and B represents the IDs of the subjects taught by Smith.

2.5 Exercise

Find the names of professors who teach at least one course with no enrolled students.

$$A := \Pi_{\text{CID}}(\text{course}) - \Pi_{\text{CID}}(\text{enrolled})$$
$$\Pi_{\text{name}}(\sigma_{\text{CID} \in A}(\text{teaches}) \bowtie \text{professor})$$

In a similar fashion to our last exmple, we use the subquery notation. We check what courses have no students enrolled and save their CIDs in the set A. We then look which professors teach these subjects.

2.6 Exercise

Find the names of students who have taken all courses offered by the Physics department.

$$\Pi_{\text{name}}(\sigma_{B \subseteq A_x}(\rho_x(\text{student})))$$
$$A_x := \Pi_{\text{CID}}(\sigma_{\text{SID = x.SID}}(\text{enrolled}))$$
$$B := \Pi_{\text{CID}}(\sigma_{\text{department = "Physics"}}(\text{course}))$$