Solutions for relational algebra exercises (Part 2)

September 2019

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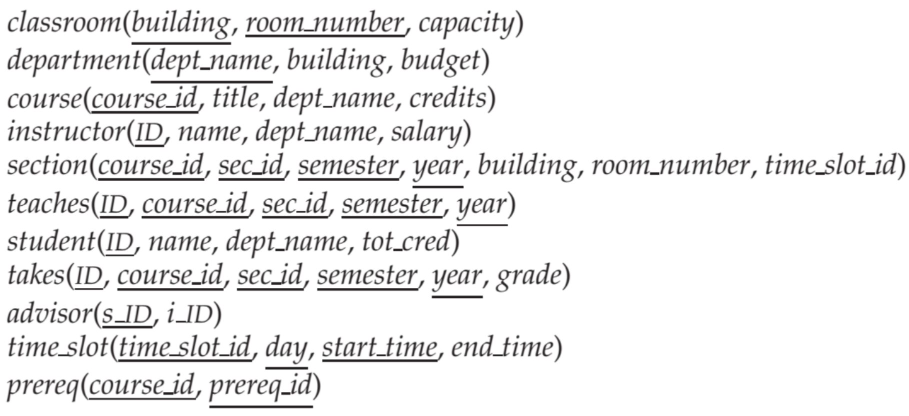
Database schema



classroom(*building*, *room_number*, *capacity*)
department(*dept_name*, *building*, *budget*)
course(*course_id*, *title*, *dept_name*, *credits*)
instructor(*ID*, *name*, *dept_name*, *salary*)
section(*course_id*, *sec_id*, *semester*, *year*, *building*, *room_number*, *time_slot_id*)
teaches(*ID*, *course_id*, *sec_id*, *semester*, *year*)
student(*ID*, *name*, *dept_name*, *tot_cred*)
takes(*ID*, *course_id*, *sec_id*, *semester*, *year*, *grade*)
advisor(*s_ID*, *i_ID*)
time_slot(*time_slot_id*, *day*, *start_time*, *end_time*)
prereq(*course_id*, *prereq_id*)

Figure 1: University database schema

Solutions

Exercise 01

a. Find the titles of courses in the Comp. Sci. department that have 3 credits.

$\Pi_{title}(\sigma_{dept\_\_name='Comp.Sci.' \ \wedge \ credits=3}(course))$

b. Find the IDs of all students who were taught by an instructor named Einstein; make sure there are no duplicates in the result.

$\Pi_{s\_\_ID}(\sigma_{name='Einstein'}(instructor) \bowtie \ teaches \bowtie \rho_{takes2[s\_\_ID,\ course\_\_id,\ sec\_\_id,\ semester,\ year,\ grade]}(takes))$

c. Find the highest salary of all instructors

Without aggregate functions

$\Pi_{salary}(instructor) - \Pi_{salary}(instructor \bowtie_{salary\ <\ salary2} \rho_{instructor2[ID2,name2,dept\_\_name2,salary2]}(instructor))$

With aggregate functions

$\mathscr{G}_{max(salary)\ as\ salary}(instructor)$

d. Find all instructors earning the highest salary (there may be more than one with the same salary)

Without aggregate functions

$\Pi_{ID,name}(instructor) - \Pi_{ID,name}(instructor \bowtie_{salary\ <\ salary2}\ \rho_{instructor2[ID2,name2,dept\_\_name2,salary2]}(instructor))$

With aggregate functions

$\Pi_{ID,name}(instructor \bowtie \mathscr{G}_{max(salary)\ as\ salary}(instructor))$

e. Find the enrollment of each section that was offered in Autumn 2009

${}_{course\_\_id,\ sec\_\_id}\mathscr{G}_{count(ID)\ as\ enrollment}(\sigma_{semester='Autumn'\ \wedge\ year=2009}(takes))$

f. Find the maximum enrollment, across all sections, in Autumn 2009.

$\mathscr{G}_{max(enrollment)\ as\ enrollment}({}_{course\_\_id,\ sec\_\_id}\mathscr{G}_{count(ID)\ as\ enrollment}(\sigma_{semester='Autumn'\ \wedge\ year=2009}(takes)))$

g. Find the sections that had the maximum enrollment in Autumn 2009.

$\Pi_{course\_\_id,\ sec\_\_id}($

$({}_{course\_\_id,\ sec\_\_id}\mathscr{G}_{count(ID)\ as\ enrollment}(\sigma_{semester='Autumn'\ \wedge\ year=2009}(takes)))$

$\bowtie$

$(\mathscr{G}_{max(enrollment)\ as\ enrollment}({}_{course\_\_id,\ sec\_\_id}\mathscr{G}_{count(ID)\ as\ enrollment}(\sigma_{semester='Autumn'\ \wedge\ year=2009}(takes))))$

$)$

Exercise 02

a. Find the names of all students who have taken at least one Comp. Sci. course.

$\Pi_{name}(student \bowtie takes \bowtie \Pi_{course\_\_id}(\sigma_{dept\_\_name='Comp.Sci.'}(course)))$

b. Find the IDs and names of all students who have not taken any course offering before Spring 2009.

$\Pi_{ID,name}(student \bowtie (\Pi_{ID}(student) - \Pi_{ID}(\sigma_{year<=2008}(takes))))$

c. For each department, find the maximum salary of instructors in that department. You may assume that every department has at least one instructor.

$_{\mathit{dept\_\_name}}\mathscr{G}_{\mathit{max(salary)}}(\mathit{instructor})$

d. Find the lowest, across all departments, of the per-department maximum salary computed by the preceding query.

$\mathscr{G}_{\mathit{min(max\_\_dept\_\_sal)}}(_{\mathit{dept\_\_name}}\mathscr{G}_{\mathit{max(salary)\ as\ max\_\_dept\_\_sal}}(\mathit{instructor}))$

Exercise 03

Write relational-algebra queries to find the course sections taught by more than one instructor in the following ways:

a. Using aggregate function(s).

$\Pi_{\mathit{course\_\_id,\ sec\_\_id,\ semester,\ year}}(\sigma_{\mathit{ins\_\_cnt}\ >\ 1}(_{\mathit{course\_\_id,\ sec\_\_id,\ semester,\ year}}\mathscr{G}_{\mathit{count(ID)\ as\ ins\_\_cnt}}(\mathit{teaches})))$

b. Without using any aggregate functions.

Using natual join

$\Pi_{\mathit{course\_\_id,\ grade,\ sec\_\_id,\ semester,\ year,}}(\sigma_{\mathit{ID<>ID2}}(\mathit{teaches} \bowtie \rho_{[\mathit{ID2,\ course\_\_id,\ sec\_\_id,\ semester,\ year}]}(\mathit{teaches})))$

Using theta join

$\Pi_{\mathit{course\_\_id,\ grade,\ sec\_\_id,\ semester,\ year,}}($
$\mathit{teaches}$
$\bowtie_{\mathit{ID<>ID2}\ \wedge\ \mathit{course\_\_id=course\_\_id2}\ \wedge\ \mathit{sec\_\_id=sec\_\_id2}\ \wedge\ \mathit{semester=semester2}\ \wedge\ \mathit{year=year2}}$
$\rho_{[\mathit{ID2,\ course\_\_id2,\ sec\_\_id2,\ semester2,\ year2}]}(\mathit{teaches})$
$)$