Chapter 4 - Relational Algebra

1. Q & A
    i. What are the PIDs of the students whose name is "Bob"?
    ii. Which pairs of students live at the same address?
    iii. Which departments have courses that have pre-requisites in other departments?
    iv. Compute the set of all courses that are their own pre-requisites.
    v. What are the names and addresses for students taking CS 513?
    vi. What are the courses (specified by course number and department name) that the head of the CS department is teaching?
    vii. Return the PID and names of any department head who teaches a course in another department?

Q & A

Consider the following scenario modelling courses, students, professors, departments, and the like at a single university in a single semester.

- Each student has a name, a unique PID, and an address. A professor has a name, a unique PID, and belongs to a department. We also want to record the age and office of the professor. Each course has a name, a number, an offering department, a classroom, and an enrollment. (This university has not yet invented the concept of university wide course numbers.) Each department offers only one course with each number.
- Each department has a unique name. Each department has at most one chairperson who is its head (there are times when a department may not have a chairperson). Each chairperson can be the head of at most one department.
- Each student enrolls in a certain number of courses in the semester. At most one professor teaches each course. Each student receives a grade in each course he/she is enrolled in. In turn, each student evaluates the professor teaching the course.
- A course can have multiple pre-requisites. A course can be a prerequisites for multiple courses. A course cannot be a pre-requisite for itself! A student enrolled in a course must have enrolled in all its pre-requisites.

In class, we came up with the following relations (or a very similar set of relations) to model this scenario:

- Students(StudentPID: string, Name: string, Address: string)
- Professors(PID: string, Name: string, Office: string, Age: integer, DepartmentName: string)
- Courses(Number: integer, DeptName: string, CourseName: string, Classroom: string, Enrollment: integer)
- Departments(Name: string, ChairPID: string)
- Take(StudentPID: string, Number: integer, DeptName: string, Grade: string, ProfessorEvaluation: integer)
- Teach(ProfessorPID: string, Number: integer, DeptName: string)
- PreReq(Number: integer, DeptName: string, PreReqNumber: integer, PreReqDeptName: string)

Write down solutions to the following questions in relational algebra:

What are the PIDs of the students whose name is "Bob"?

$$\prod_{\texttt{studentpid}}(\sigma_{\texttt{name="Bob"}}(\texttt{Students}))$$

Which pairs of students live at the same address?

$$\texttt{R0} \coloneqq P_{\texttt{(pid,sname,address)}}(\texttt{Students}))$$
$$\texttt{R1} \coloneqq \texttt{Students} \bowtie_{\texttt{Students.address=R0.address}} (\texttt{R0})$$
$$\texttt{R2} \coloneqq \prod_{\texttt{(Students.name,sname,Students.address)}}(\sigma_{\texttt{studentpid<>pid}}(\texttt{R1}))$$

Which departments have courses that have pre-requisites in other departments?

$$\prod_{\text{deptname}}(\sigma_{\text{deptame}<>\text{prereqdeptname}}(\text{PreReq}))$$

Compute the set of all courses that are their own pre-requisites.

The purpose of this query is to ensure that the constraint "A course cannot be a pre-requisite for itself" holds in the database. Your query needs to return only the course number and department name.

$$\prod_{(\text{number},\text{deptname})}(\sigma_{(\text{deptame}=\text{prereqdeptname AND number}=\text{prereqnumber})}(\text{PreReq}))$$

What are the names and addresses for students taking CS 513?

$$R1 := \text{Students} \bowtie_{(\text{Students.studentpid}=\text{Take.studentpid})} \text{Take}$$
$$\prod_{(\text{name},\text{address})}(\sigma_{(\text{R1.number}=513 \text{ AND R1.deptname}=\text{"CS"})}(R1))$$

What are the courses (specified by course number and department name) that the head of the CS department is teaching?

$$R0 := \text{Teach} \bowtie_{(\text{Teach.professorpid}=\text{Departments.chairpid AND Departments.name}=\text{"CS"})} \text{Departments}$$
$$\prod_{(\text{number},\text{deptname})}(R0)$$

Return the PID and names of any department head who teaches a course in another department?

$$R0 := \text{Departments} \bowtie_{(\text{chairpid}=\text{professorpid})} \text{Teach}$$
$$R1 := \prod_{(\text{chairpid})}(\sigma_{\text{name}<>\text{deptname}}(R1))$$
$$\prod_{(\text{chairpid},\text{name})}(\text{Professors} \bowtie_{\text{pid}=\text{chairpid}} R1)$$

---- Jason, 09/20/2016