CSCC43: Introduction to Databases
Assignment 1
Solution Version 2

Out: June 1, 2005
Due: June 14, at the beginning of the lecture

This assignment must by typed. Handwritten assignments will **not be remarked**. Pages must be numbered. Make sure there are no pages missing.

Exercise 1

Consider the following schema for a database recording information about a research lab. The research lab, composed of several research units, employs researchers, interns, lab and administrative staff who work on various projects. A researcher may supervise students and be involved in sevarl research projects. Every intern is supervised by a researcher and may work on several research projects. All research units and projects are managed by a researcher.

$Researcher(\underline{r\_number}, r\_name, category, r\_salary, r\_area, ru\_code)$

$Intern(\underline{i\_number}, i\_name, i\_start\_date, duration, salary, r\_number)$

$Lab\_staff(\underline{s\_number}, l\_name, l\_start\_date, salary, clearance, area)$

$Administrative\_staff(\underline{s\_number}, a\_name, a\_start\_date, salary, description, experience)$

$Project(\underline{p\_code}, start\_date, budget, duration, r\_number, ru\_code)$

$Research\_unit(\underline{ru\_code}, security\_level)$

$Intern\_project(\underline{i\_number, p\_code})$

$Researcher\_project(\underline{r\_number, p\_code})$

$Staff\_project(\underline{s\_number, p\_code})$

$Staff\_lab(\underline{s\_number, ru\_code})$

$Manages(\underline{r\_number, ru\_code})$

The following (inclusion dependencies) hold:

$\pi_{i\_number}(Intern\_project) \subset \pi_{i\_number}(Intern)$

$\pi_{p\_code}(Intern\_project) \subset \pi_{p\_code}(Project)$

$\pi_{r\_number}(Researcher\_project) \subset \pi_{r\_number}(Researcher)$

$\pi_{p\_code}(Researcher\_project) \subset \pi_{p\_code}(Project)$

$\pi_{s\_number}(Staff\_project) \subset \pi_{s\_number}(Lab\_staff)$

$\pi_{p\_code}(Staff\_project) \subset \pi_{p\_code}(Project)$

$\pi_{r\_number}(Manages) \subset \pi_{r\_number}(Researcher)$

$\pi_{ru\_code}(Manages) \subset \pi_{ru\_code}(Research\_unit)$

Part 1 - Relational algebra (50 marks)

1. (10 marks) Find the names of the researchers who are involved in exactly 3 projects.

   $R_1 = \Pi_{r\_number}(\sigma_{p\_code1 \neq p\_code2 \wedge p\_code1 \neq p\_code3 \wedge p\_code2 \neq p\_code3}(Researcher \bowtie \rho_{r\_number,p\_code1}(Researcher\_project) \bowtie \rho_{r\_number,p\_code2}(Researcher\_project) \bowtie \rho_{r\_number,p\_code3}(Researcher\_project)))$

   R_1 represents researchers who are involved in at least 3 projects

   $R_2 = \Pi_{r\_number}(\sigma_{p\_code1 \neq p\_code2 \wedge p\_code1 \neq p\_code3 \wedge p\_code1 \neq p\_code4 \wedge p\_code2 \neq p\_code3 \wedge p\_code2 \neq p\_code4 \wedge p\_code3 \neq p\_code4}($
   $Researcher \bowtie \rho_{r\_number,p\_code1}(Researcher\_project) \bowtie \rho_{r\_number,p\_code2}(Researcher\_project) \bowtie$
   $\rho_{r\_number,p\_code3}(Researcher\_project) \bowtie \rho_{r\_number,p\_code4}(Researcher\_project)))$

   R_2 represents researchers who are involved in at least 4 projects

Answer $= \Pi_{r\_name}((R_1 - R_2) \bowtie Researcher)$

2. (10 marks) List the researchers who work for all the projects that involve at least one of their interns.

   $R1 = \Pi_{r\_number,p\_code}(Researcher \bowtie Researcher\_project \bowtie Intern \bowtie Intern\_project)$

   R_1 contains pairs (r_number, p_code) such that the researcher with id r_number and one of his/her interns works on the project with id p_code.

   $R2 = \Pi_{r\_number,p\_code}(Researcher \bowtie Intern \bowtie Intern\_project)$

   R_2 contains pairs (r_number, p_code) such that an intern of the researcher with id r_number works on the project with id p_code.

   Answer $= (\Pi_{r\_number}(R_1) - \Pi_{r\_number}(R_2 - R_1)) \bowtie Researcher$

3. (10 marks) List the researchers who coordinate projects for which at least 3 students whom they do not supervise work for.

   Answer $= \Pi_{r\_number}(\sigma_{i\_number1 \neq i\_number2 \wedge i\_number1 \neq i\_number3 \wedge i\_number2 \neq i\_number3}(Researcher \bowtie Project \bowtie$
   $\rho_{i\_number1,i\_name1,i\_start\_date1,duration1,salary1,r\_number1}(Intern) \bowtie \rho_{i\_number1,p\_code}(Intern\_project) \bowtie$
   $\rho_{i\_number2,i\_name2,i\_start\_date2,duration2,salary2,r\_number2}(Intern) \bowtie \rho_{i\_number2,p\_code}(Intern\_project \bowtie$
   $\rho_{i\_number3,i\_name3,i\_start\_date3,duration3,salary3,r\_number3}(Intern) \bowtie \rho_{i\_number3,p\_code}(Intern\_project)) \bowtie$
   $Researcher$

4. (10 marks) Find the names of the researchers who coordinate only projects that are associated with their research unit.

   Answer $= \Pi_{r\_name}((\Pi_{r\_number}(Project)$ -

   $\Pi_{r\_number}(\sigma_{Researcher.ru\_code \neq Project.ru\_code \wedge Researcher.r\_number = Project.r\_number}(Researcher \times Project)) \bowtie$
   $Researcher)$

5. (10 marks) List the codes of projects whose managers do not work on any other projects.

   Answer $= \Pi_{r\_number}(Project) -$

   $\Pi_{p\_code}(\sigma_{p\_code \neq p\_code1}(Project \bowtie \rho_{r\_number,p\_code1}(Researcher\_project)))$

Part 2 - Relational Calculus (40 marks)

Note: Tuple Relational Calculus and Domain Relational Calculus are both acceptable.

1. (10 marks) Find the researchers who coordinate the projects with the biggest budget.

   $\{a | Researcher(a) \wedge \exists p, Project(p) \wedge \wedge a.r\_number = p.r\_number \wedge (\forall p_1, Project(p_1) \rightarrow p_1.budget < p.budget)\}$

2. (10 marks) Find the researchers who have no supervised interns who work for projects they coordinate.

   $\{a | Researcher(a), \neg(\exists i, p, t, Intern(i) \wedge Project(p) \wedge Intern\_project(t) \wedge p.r\_number = a.r\_number \wedge t.i\_number = i.i\_number \wedge p.p\_code = t.p\_code \wedge a.r\_number = i.r\_number)\}$

3. (10 marks) List the projects coordinated by researchers who have interns working for all the projects they are involved in.

   $\{p | Project(p) \wedge (\forall w, (Researcher\_project(w) \wedge w.r\_number = p.r\_number) \rightarrow (\exists i, Intern(i) \wedge$

   $i.r\_number = p.r\_number \wedge ip.p\_code = w.p\_code \wedge i.i\_number = ip.i\_number))\}$

4. (10 marks) Find the researchers with the second highest salary.

   $\{a | Researcher(a) \wedge \exists r_1, Researcher(r_1) \wedge a.salary < r_1.salary \wedge (\forall r, (Researcher(r) \wedge r.salary \neq r_1.salary \wedge r.salary \neq a.salary) \rightarrow r.salary <= a.salary)\}$