CSC343: Introduction to Databases
Assignment 1
Solution Version 2

Out: May 30, 2005
Due: June 13, 2005

Exercise 1

Part 1 - Relational algebra (50 marks)

1. (10 marks) Find projects where only one employee works on, the project manager.

   $R_1 = \Pi_{Project.prID}(\sigma_{Project.prMngID=WorksOn.eID}(Project \bowtie WorksOn))$

   R_1 contains the projects on which the manager of the project actually works.

   $R_2 = \Pi_{prID}(\sigma_{eID1=prMngID \wedge eID1 \neq eID2}(Project \bowtie \rho_{eID1,prID}(WorksOn) \bowtie \rho_{eID2,prID}(WorksOn)))$

   R_2 contains the projects on which the manager of the project and at least one other employee work.

   Answer $= R_1 - R_2$

2. (10 marks) Find companies where at least 3 of their employees commute (they live in a city other than that where the company is located), and they work only for this company.

   $R_1 = \Pi_{cID,eID1,eID2,eID3}($

   $\sigma_{city1 \neq city \wedge city2 \neq city \wedge city3 \neq city \wedge eID1 \neq eID2 \wedge eID1 \neq eID3 \wedge eID2 \neq eID3}$

   $(Company \bowtie$

   $\rho_{deptID1,cID,deptName1,mngID1,emplNo1}(Department) \bowtie \rho_{eID1,deptID1}(WorksIn) \bowtie \rho_{eID1,eName1,city1,salary1,age1}(Employee) \bowtie$

   $\rho_{deptID2,cID,deptName2,mngID2,emplNo2}(Department) \bowtie \rho_{eID2,deptID2}(WorksIn) \bowtie \rho_{eID2,eName2,city2,salary2,age2}(Employee) \bowtie$

   $\rho_{deptID3,cID,deptName3,mngID3,emplNo3}(Department) \bowtie \rho_{eID3,deptID3}(WorksIn) \bowtie \rho_{eID3,eName3,city3,salary3,age3}(Employee)))$

   $R_2 = \Pi_{cID,eID1,eID2,eID3}($

   $\sigma_{city1 \neq city \wedge city2 \neq city \wedge city3 \neq city \wedge eID1 \neq eID2 \wedge eID1 \neq eID3 \wedge eID2 \neq eID3 \wedge (cID11 \neq cID \vee cID22 \neq cID \vee cID33 \neq cID)}$

   $(Company \bowtie$

   $\rho_{deptID1,cID,deptName1,mngID1,emplNo1}(Department) \bowtie \rho_{eID1,deptID1}(WorksIn) \bowtie \rho_{eID1,eName1,city1,salary1,age1}(Employee) \bowtie$

   $\rho_{deptID11,cID11,deptName11,mngID11,emplNo11}(Department) \bowtie \rho_{eID1,deptID11}(WorksIn) \bowtie$

   $\rho_{deptID2,cID,deptName2,mngID2,emplNo2}(Department) \bowtie \rho_{eID2,deptID2}(WorksIn) \bowtie \rho_{eID2,eName2,city2,salary2,age2}(Employee) \bowtie$

   $\rho_{deptID22,cID22,deptName22,mngID22,emplNo22}(Department) \bowtie \rho_{eID2,deptID22}(WorksIn) \bowtie$

   $\rho_{deptID3,cID,deptName3,mngID3,emplNo3}(Department) \bowtie \rho_{eID3,deptID3}(WorksIn) \bowtie \rho_{eID3,eName3,city3,salary3,age3}(Employee)$

   $\rho_{deptID33,cID33,deptName33,mngID33,emplNo33}(Department) \bowtie \rho_{eID3,deptID33}(WorksIn)))$

   Answer $= \Pi_{cID}(R_1 - R_2)$

3. (10 marks) Find employees who were the project manager of all the expensive projects they worked on. An expensive project is one that costs more than 1,000,000.

   $R_1 = \Pi_{eID,prID}(\sigma_{prMngID=eID \wedge cost>1000000}(Project \bowtie WorksOn))$

   $R_2 = \Pi_{eID,prID}(\sigma_{cost>1000000}(Project \bowtie WorksOn))$

   Answer $= \Pi_{eID}(R_1) - \Pi_{eID}(R_2 - R_1)$

4. (10 marks) Among the youngest employees of "Intel", find those who have the highest salary.

   $R_1 = \Pi_{eID1,salary1}($

   $\sigma_{cName1="Intel" \wedge cName2="Intel" \wedge age1>age2}$

   $((\rho_{cID1,cName1,city1,country1,country1,assets1}(Company) \bowtie \rho_{deptID1,cID1,deptName1,mngID1,emplNo1}(Department) \bowtie$

   $\rho_{eID1,deptID1}(WorksIn) \bowtie \rho_{eID1,eName1,city11,salary1,age1}(Employee))$

$\times$
$(\rho_{cID2,cName2,city2,country2,country2,assets2}(Company) \bowtie \rho_{deptID2,cID2,deptName2,mngID2,emplNo2}(Department) \bowtie$
$\rho_{eID2,deptID2}(WorksIn) \bowtie \rho_{eID2,eName2,city22,salary2,age2}(Employee))))$

R2 = The youngest employees of Intel

$R_2 = \Pi_{eID,slary}(\sigma_{cName="Intel"}(Employee \bowtie Department \bowtie WorksIn \bowtie Company) - \rho_{eID,salary}(R_1))$

$R_3 = \Pi_{eid3,salary3}(\sigma_{eID \neq eID3 \wedge salary > salary3}(R_2 \times \rho_{eID3,salary3}(R_2)))$

Answer $= R_2 - R_3$

5. (10 marks) Find all "salary anomalies": that is pairs (e_1, e_2) of employees (their IDs) both working for the same company, one is a department manager, the other is a project manager, and the second employee has a salary higher than that of the first employee.

$R1 = \rho_{deptID1,cID1,deptName1,mngID1,emplNo1}(Department)$

$R2 = \rho_{eID2,deptID2}(WorksIn)$

$R3 = \rho_{eID3,eName3,city3,salary3,age3}(Employee)$

$R4 = \rho_{deptID4,cID4,deptName4,mngID4,emplNo4}(Department)$

$R5 = \rho_{prID5,deptID5,prMng5,cost5}(Project)$

$R6 = \rho_{eID6,eName6,city6,salary6,age6}(Employee)$

$R7 = \rho_{eID7,deptID7}(WorksIn)$

$R8 = \rho_{deptID8,cID8,deptName8,mngID8,emplNo8}(Department)$

$Answer = \Pi_{eID3,eID6}($

$\sigma_{deptID1=deptID2 \wedge deptID2=deptID3 \wedge deptID6=deptID7 \wedge deptID7=deptID8}($

$\sigma_{((mngID4=eID3 \wedge eID6=prMngID5) \wedge (mngID4=eID6 \wedge eI D3=prMngID5)) \wedge cID1=cID8 \wedge salary6 > salary3}($

$R1 \times R2 \times R3 \times R4 \times R5 \times R6 \times R7 \times R8))$

Part 2 - Relational Calculus (40 marks)

1. (10 marks) Find employees who spend at least 3 companies, all located in the same city, and the departments in which they work in these companies have all the same name.

Answer $=\{e | \exists d_1, d_2, d_3, c_1, c_2, c_3, w_1, w_2, w_3, Employee(e) \wedge Department(d_1) \wedge Department(d_2) \wedge Department(d_3) \wedge$
$Company(c_1) \wedge Company(c_2) \wedge Company(c_3) \wedge WorksIn(w_1) \wedge WorksIn(w_2) \wedge WorksIn(w_3) \wedge$
$d_1.cID \neq d_2.cID \wedge d_1.cID \neq d_3.cID \wedge d_2.cID \neq d_3.cID \wedge d_1.cID = c_1.cID \wedge d_2.cID = c_2.cID \wedge d_3.cID = c_3.cID \wedge c_1.city = c2.city \wedge c_1.city = c3.city \wedge d_1.deptName = d_2 deptName \wedge d_1.deptName = d_3.deptName \wedge d_1.deptID = w_1.deptID \wedge d_2.deptID = w_2.deptID \wedge d_3.deptID = w_3.deptID \wedge e.eID = w_1.eID \wedge e.eID = w_2.eID \wedge e.eID = w_3 \wedge \}$

2. (10 marks) Find the ids and names of the employees who work on all the projects their department develops.

Answer $= \{e | \exists e_1, Employee(e_1) \wedge e.eID = e_1.eID \wedge e.eName = e1.eName \wedge (\forall p, (Project(p) \wedge (\exists w, WorksIn(w) \wedge w.eID = e.eID \wedge w.deptID = p.deptID)) \rightarrow (\exists u, WorksOn(u) \wedge u.prID = p.prID \wedge u.eID = e.eID))\}$

3. (10 marks) Find the departments with the highest number of employees in the company with the smallest assets

Answer $= \{d | \exists c, Comapny(c) \wedge Department(d) \wedge d.cID = c.cID \wedge (\forall c_1, Company(c_1) \rightarrow (c_1.assets > c.assets)) \wedge$
$(\forall d_1, (Department(d_1) \wedge d_1.cID = c.cID) \rightarrow d_1.emplNo < d.emplNo)\}$

4. (10 marks) Check if the following anomaliy happens: there is a department where there are employees working on the projects developed in that department, and who are not employed in that department.

Answer $= \exists e, d, p, w, Employee(e) \wedge Department(d) \wedge Project(p) \wedge WorksOn(w) \wedge p.deptID = d.deptID \wedge w.eID = e.eID \wedge w.prID = p.prID \wedge (\forall u, WorksIn(u) \rightarrow (e.eID \neq u.eID \vee u.deptID \neq d.deptID))$

5. (10 marks) Find the salary of the manager of IBM Canada department where the most expensive project of this company is developed.

Answer $= \{a | \exists e, d, c, p, Employee(e) \wedge Department(d) \wedge Company(c) \wedge Project(p) \wedge$
$a.salary = e.salary \wedge e.eID = d.mngID \wedge d.cID = c.cID \wedge p.deptID = d.deptID \wedge c.cName = "IBM" \wedge c.country = "Canada" \wedge$
$(\forall p_1, (Project(p_1) \wedge (\exists d_1, Department(d_1) \wedge d_1.deptID = p1.deptID \wedge d_1.cID = c.cID)) \rightarrow p_1.cost < p.cost)\}$