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Data Models and Query Languages
Summerterm 2014

1. Exercise Sheet: Relational Algebra and Conjunctive Queries

Submission: 08.05.2014, 14:00
Discussion: 08.05.2014

Submission Guidlines: Please hand out your written solutions directly to your tutors right before the exercise session. If you want to submit before the deadline, you can leave your solutions in the mail box in building 51-01 (first floor). Hand written solutions are also accepted as long as these are readable.

Review of Relational Algebra

We have published a summary of definitions of Database Foundations in English at:
`http://dbis.informatik.uni-freiburg.de/lehre/SS14/Spezialvorlesung/Data+Models+and+Query+Languages/exercises.html`

Exercise 1 (Relational Algebra)

a) In the above mentioned slides the definition of two Relational Algebra operators are missing. Provide a definition for cartesian product ($\times$) and division ($\div$).

b) Consider the following database schema.

- `Professor`(*ProfName*, *DeptName*)
- `Department`(*DeptName*, *DeptBuilding*)
- `Conference`(*ConfName*, *ProfName*, *ConfYear*)

Write a relational algebra expression for each of the following queries:

(a) Find all the professors whose chairs are located in buildings 51 and 52 and who took part in conferences in 2000.

(b) Find all the professors who were in any of the conferences in which Professor 'Lausen' took part in 2014.

(c) Find all the professors who were in at least all those conferences in which Professor 'Lausen' took part between 2000 to 2014 ([2000, 2014]).

c) Let R, S and T be relations with formats X, Y and Z respectively. Using the definitions of Relational Algebra operators, prove the following equivalences:

(a) $R \bowtie R \equiv R$

(b) $X = Y \Rightarrow R \cap S \equiv R \bowtie S$

(c) $Z \subseteq Y \subseteq X \Rightarrow \pi[Z](\pi[Y]R) \equiv \pi[Z]R$

d) Consider two relations with schema R(A, B) and S(B, C) and their respective instances r and s. The following relational algebra expressions are not equivalent:
   (a) $\pi[A, C](\pi[A]r \times \sigma[B = 0]s)$
   (b) $\pi[A](\sigma[B = 0]r) \times \pi[C](\sigma[B = 0]s)$
   Give a database instance that proves that both expressions are not equivalent.

Graded exercises

Exercise 2 (SQL, Relational Algebra and Conjunctive Queries, 3+3+3+1=10 Points)
Consider the following database schema.

- `Author`(*AuthID*, *AuthName*, *AuthAdress*)
- `Paper`(*PaperID*, *PaperTitle*, *PaperRating*)
- `Publication`(*AuthID*, *PaperID*)

Assume moreover, that $dom(PaperRating) = \{0, 1, 2, 3, 4, 5\}$. Rewrite the following queries in SQL, relational algebra and as a conjunctive query (if possible).

a) Select those papers (title) published by author 'Lausen' which got a rating higher than (>) 4 (3 pts.).
b) Select those papers (title) published by author 'Lausen' which got a rating higher than (>) 3 (3 pts.).
c) A paper can be written by more than one author. Select those papers written at least by 'Lausen' and a second author if he lives in Freiburg (3 pts.).

Write an SQL query which is expressible as a relational algebra expression but is not expressible as a conjunctive query (1 pt.).

Exercise 3 (Containment Mapping and equivalence, 4+4+2=10 Points)
a) Consider the following conjunctive queries Q_1, Q_2 and decide whether $Q_1 \sqsubseteq Q_2$, $Q_2 \sqsubseteq Q_1$, and $Q_1 \equiv Q_2$ hold. Provide the corresponding containment mappings or show that no such mapping exists (4 pts.).
   - $Q_1 : ans(X) \leftarrow R(X, Y), S(Y, Z), S(W, C)$
   - $Q_2 : ans(Y) \leftarrow S(A, B), R(Y, A), R(W, A)$

b) Consider the following conjunctive queries Q_1, Q_2 and decide whether $Q_1 \sqsubseteq Q_2$, $Q_2 \sqsubseteq Q_1$, and $Q_1 \equiv Q_2$ hold applying the corollary on slide 20 (canonical instance method) (4 pts.).
   - $Q_1 : ans(X) \leftarrow R(X, Y), R(Y, Z), R(Z, X)$
   - $Q_2 : ans(X) \leftarrow R(X, Y), R(Y, Z), R(Z, W), R(W, V)$

c) Consider the following two conjunctive queries, where c denotes a constant.
   - $Q_1 : ans(X, W) \leftarrow R(X, Y), R(Y, c), R(c, B), R(B, W)$
   - $Q_2 : ans(X, W) \leftarrow R(X, Y), R(Y, B), R(B, V), R(V, W)$

   Is it possible to apply the method of containment mapping to show whether $Q_1 \sqsubseteq Q_2$, $Q_2 \sqsubseteq Q_1$, or $Q_1 \equiv Q_2$? If yes, find the valid containments and provide the corresponding solution mappings (2 pts.)