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Foundations of Query Languages
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4. Exercise Set: Conjunctive Queries

Exercise 1
Consider the following four Conjunctive Queries, where c denotes a constant.

- $q_1 : ans(X,Y) \leftarrow R(X,A), R(A,B), R(B,Y)$
- $q_2 : ans(X,Y) \leftarrow R(X,A), R(A,B), R(B,C), R(C,Y)$
- $q_3 : ans(X,Y) \leftarrow R(X,A), R(B,C), R(D,Y), R(X,B), R(A,C), R(C,Y)$
- $q_4 : ans(X,Y) \leftarrow R(X,A), R(A,c), R(c,B), R(B,Y)$

a) Find all equivalences and containment relationships between the above queries. If two queries are not contained in each other, then give a database instance that witnesses this fact.

b) Minimize all queries.

Exercise 2
Prove the following claim. For every conjunctive query q and all database instances I and J we have that if $I \subseteq J$, then $q(I) \subseteq q(J)$.

Hint: Recall that we consider a database instance as a set of atoms in this chapter on conjunctive queries.

Exercise 3
Consider the following database scheme.

- `Sales`(*PName*,*SName*,*CName*)
- `Part`(*PName*,*Type*)
- `Cust`(*CName*,*CAddr*)
- `Supp`(*SName*,*SAddr*)

Further assume that the attributes *CAddr* and *SAddr* store the point of origin of the customers and suppliers, respectively. Specify the following queries in SQL and – whenever possible – as a conjunctive query. If a query cannot be expressed as a conjunctive query, then prove your claim.

Hint: In order to show that a query cannot be expressed as a conjunctive query, you may want to use the previous exercise.

a) Part-, supplier-, and customer name of all parts of type "*typ1*" that have been bought from a customer living in Freiburg.

b) All parts of type "*typ2*" that have been bought from both customer "*Meier*" and customer "*Smith*".

c) All parts that have never been sold.

Exercise 4

In the lecture slides it was mentioned that deciding containment of two conjunctive queries is NP-complete.

- Given the boolean formula $\alpha := (x_1 \vee \neg x_2 \vee \neg x_3) \wedge (x_3 \vee x_3 \vee x_2) \wedge (\neg x_3 \vee \neg x_1 \vee \neg x_2)$ as input, construct the corresponding queries q_1 and q_2 from the proof of this theorem such that α is satisfiable iff $q_1 \sqsubseteq q_2$.
- Describe in your own words why this construction works, i.e. explain why we have that α is satisfiable iff $q_1 \sqsubseteq q_2$ for an arbitrary input formula α. (Not just for the α from the previous part.)

Due by: May 19, 2010 before the tutorial starts.