Universität Freiburg
Institut für Informatik
Michael Meier
Michael Schmidt

Georges-Köhler Allee, Geb. 51
D-79110 Freiburg
Tel. (0761) 203-8126
Tel. (0761) 203-8127

Foundations of Query Languages
Summer semester 2010
April 21, 2010

1. Exercise Set: FOL and its Relationship to Databases

Exercise 1 (Modelling in FOL)
Consider the following database scheme $\{A, E, c, d\}$, where A is a unary relational symbol, E is a 2-ary relational symbol and c, d are constants. Let the database $(A^{\mathcal{A}}, E^{\mathcal{A}}, c^{\mathcal{A}}, d^{\mathcal{A}})$ be given ($A^{\mathcal{A}}, E^{\mathcal{A}}$ are finite). We interpret $A^{\mathcal{A}}$ as the set of all philisophers, $E^{\mathcal{A}}(a, b)$ means that "a is a student of b" or equivalently "b is a teacher of a" and $c^{\mathcal{A}} =$ Aristotle, $d^{\mathcal{A}} =$ Platon. Further assume that $E^{\mathcal{A}} \subseteq A^{\mathcal{A}} \times A^{\mathcal{A}}$ and $c^{\mathcal{A}}, d^{\mathcal{A}} \in A^{\mathcal{A}}$. Write down in first-order logic:

a) Every student of Aristotle is also a student of Platon.

b) Aristotle is a student and Platon is a teacher.

c) All philosophers are either students of Platon or students of Aristotle.

d) Aristotle has at least two students that are teachers.

Exercise 2 (Semantics of FOL)
Let the database scheme $\{P, Q, R\}$ be given, where P, Q are unary relational symbols and R is a binary relational symbol. Let

$$\varphi := \forall x_1 (P(x_1) \Rightarrow \exists x_2 (\neg R(x_3, x_2) \vee Q(x_1))).$$

Give a relational structure $\mathcal{A}$ und two assignments of variables, $\overline{a}$, $\overline{b}$ such that $\mathcal{A} \models \varphi[\overline{a}]$ and $\mathcal{A} \not\models \varphi[\overline{b}]$.

Exercise 3 (Query Reformulation)
Let the schema $Flight(From, To, Date), City(Id, Name)$ from the lecture slides be given and let

$$\varphi := \pi_{Name,Date}(\sigma_{\text{From}=\text{“}FRA\text{“}}(\sigma_{\text{To}=\text{Id}}(\text{Flight} \times \text{City}))) \ .$$

Rewrite this query to an equivalent query in the relational calculus.

Exercise 4 (RA vs. SQL)
Show that every relational algebra expression can be equivalently expressed in SQL. Relational algebra contains the following operations: constant relations, selection, projection, join rename, difference and union.

Hint: Recall that SQL uses bag semantics and relational algebra does not.

Exercise 5 (Domain Independence)
Which of the following queries are range-restricted and which are domain-independent? Justify your answers. In case of a query that is not domain-independent give domains (togehter with a structure) that lead to different results.

a) $\{< x, y >| \exists z[R(x, z) \wedge \exists w S(w, x, y)] \wedge x = y\}$
b) $\{< x, y >| [x = a \vee \exists z R(y, z)] \wedge T(y)\}$
c) $\{< x >| \forall y[T(y) \rightarrow R(x, y)]\}$
d) $\{<>| \exists x \forall y[T(y) \rightarrow R(x, y)]\}$

Due by: April 28, 2010 before the tutorial starts.

Literature: S. Abiteboul, R. Hull, V. Vianu: *Foundations of Databases*, Addison-Wesley, 1995. ISBN 0-201-53771-0. Download available at `http://www.inf.unibz.it/~nutt/FDBs0809`.