Ontology and Database Systems: Foundations of Databases

– Mock Exam –

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Queries in Relational Algebra and Calculus

Suppose a boat club has a database with the schema

$$\texttt{Boat}(\texttt{bname}, \texttt{type}, \texttt{colour})$$
$$\texttt{Reservation}(\texttt{mname}, \texttt{bname}, \texttt{day})$$

which records information about the boats owned by the club and about which member has reserved which boat on which day.

Consider the following two queries:

1. "Which members have only reserved red boats? "

2. "Which members made reservations for every boat of type dinghy?"

Express each query

(i) in relational algebra

(ii) in relational calculus, that is, as an expression of the form

$$\{\, x \mid \phi(x) \,\}$$

where x is the variable for which we want bindings and $\phi(x)$ is a logical formula with free variable x.

Safety and Domain Independence of Queries

Consider the following four queries expressed in relational calculus:

1. $\{\, x, y \mid \exists z\, \texttt{hasChild}(x, z) \vee \exists w\, \texttt{hasChild}(w, y) \,\}$
2. $\{\, x \mid \texttt{rich}(x) \wedge \forall y\, (\texttt{hasChild}(x, y) \rightarrow \neg\texttt{rich}(y)) \,\}$
3. $\{\, x \mid \texttt{rich}(x) \wedge \forall y\, (\neg\texttt{hasChild}(x, y) \rightarrow \texttt{rich}(y)) \,\}$

For each query, determine whether or not it is

- safe
- domain-independent.

For each query and each property, if your answer is "yes", briefly and informally explain your answer. If your answer is "no", provide an example showing that the query does not have the property in question.

Containment

In this question, we only consider relational conjunctive queries, that is, queries that do not contain comparisons.

Suppose q_0 is a fixed conjunctive query.

- The **container problem** for q_0 is the following decision problem:

  Given a conjunctive query q, decide whether $q_0 \subseteq q$.

- The **containee problem** for q_0 is the following decision problem:

  Given a conjunctive query q, decide whether $q \subseteq q_0$.

Prove or disprove the following statements:

1. For every conjunctive query q_0, there is a polynomial time algorithm to decide the *container problem* for q_0.

2. For every conjunctive query q_0, there is a polynomial time algorithm to decide the *containee problem* for q_0.

To prove a statement, a sketch of an algorithm together with a short argument why it is polynomial is sufficient. To disprove the statement, find a query q_0 for which the problem in question is NP-hard. Again, a proof sketch is sufficient to show the NP-hardness.

Translation of Queries

Suppose a library has a database with the schema

$$\texttt{book}(\texttt{bookid}, \texttt{author}, \texttt{title}, \texttt{language})$$
$$\texttt{borrows}(\texttt{reader}, \texttt{bookid}, \texttt{date}),$$

which records information about books and about which reader has borrowed which books at which date.

(i) Consider the following query, expressed in relational algebra:

$$\pi_{\texttt{reader}}(\texttt{borrows}) \setminus \pi_{\texttt{reader}}(\texttt{borrows} \bowtie \sigma_{\texttt{language}='\texttt{English}'}(\texttt{book}))$$

Express the query equivalently in

- Relational Calculus (i.e., first order predicate logic)
- SQL

(ii) Consider the following query, expressed using rules:

$$\begin{aligned}\texttt{ans}(R) \;&:\!-\; \texttt{borrows}(R, B1, D),\ \texttt{book}(B1, '\texttt{Dickens}', T1, L1),\\ & \texttt{borrows}(R, B2, D),\ \texttt{book}(B2, '\texttt{Scott}', T2, L2)\\ \texttt{ans}(R) \;&:\!-\; \texttt{borrows}(R, B1, D),\ \texttt{book}(B1, A1, T1, '\texttt{English}'),\\ & \texttt{borrows}(R, B2, D),\ \texttt{book}(B2, A2, T2, '\texttt{French}')\end{aligned}$$

Express the query equivalently in

- Relational Algebra
- SQL.