UNIVERSITY OF VICTORIA, DEPARTMENT OF COMPUTER SCIENCE

Assignment 1

CSC 370, Fall 2013

Due: October 2, 2013 (handed in class at start of lecture)

What you must submit

- Handwritten submission are acceptable. Ensure your answers are legible.
- You must have a cover sheet at the front of your submission (course, assignment, name, student number).
- All sheets must be stapled together. *The teaching team will not be responsible for missing pages or incomplete answers associated with unstapled submissions.*
- Please show all work! (Several questions remind you to do so.)

Question 1 (15 marks)

Given two relations R and S, where R contains M tuples, S contains N tuples, and $M > N > 0$, give the *minimum* and *maximum* possible sizes (in tuples) for the relation resulting from each of the following expressions. For each case, you must state any assumptions about the schemas for R and S needed to ensure expressions are meaningful.

(a) $R \cup S$

(b) $R \cap S$

(c) $R - S$

(d) $R \times S$

(e) $\sigma_{a=5}(R)$

(f) $\pi_a(R)$

(g) $R \bowtie S$

Question 2 (30 marks)

Consider the following schema:

```
Suppliers(sid, sname, address)
Parts(pid, pname, colour)
Catalog(sid, pid, cost)
```

The key for `Suppliers` is `sid`, for `Parts` is `pid`, and for `Catalog` is `sid` and `pid`. The `Catalog` relation associates prices charged for parts by suppliers.

Write the following queries using relational algebra. For items (a) through (e), use the "sequences of assignments" form. For items (f) and (g), use the "expression tree" form. List all assumptions. (Some marks will be given for the quality of your answers.)

(a) Find the names of suppliers who supply some blue part.

(b) Find the ids of suppliers who supply some blue or magenta part.

(c) Find the ids of suppliers who supply every magenta part.

(d) Find the ids of suppliers who supply every part.

(e) Find the ids of parts supplied by at least two different suppliers.

(f) Find the ids of the most expensive parts supplied by company name named "Screw-2-You Limited".

(g) Find the ids of parts supplied by every supplier at less than or equal to \$50. (If any supplier either does not supply the part or charges more than \$50 for it, then that part should not be in the final relation.)

Question 3 (25 marks)

Recall the schema from Question 2. Using natural language describe what is computed by the following queries. Make sure the rules of precedence as given in lectures are followed. Some marks will be given for the quality of your answer (that is, simply describing the query literally will not result in full marks).

(a) $\pi_{sname}(\pi_{sid}(\sigma_{colour=\text{“blue”}}(\texttt{Parts})) \bowtie (\sigma_{cost<100}(\texttt{Catalog})) \bowtie \texttt{Suppliers})$

(b) $\pi_{sname}(\pi_{sid}((\sigma_{colour=\text{“green”}}(\texttt{Parts})) \bowtie (\sigma_{cost<25.5}(\texttt{Catalog})) \bowtie \texttt{Suppliers}))$

(c) $(\pi_{sname}((\sigma_{colour=\text{“puce”}}(\texttt{Parts})) \bowtie (\sigma_{cost<50}(\texttt{Catalog})) \bowtie \texttt{Suppliers})) \cap$
$(\pi_{sname}((\sigma_{colour=\text{“cyan”}}(\texttt{Parts})) \bowtie (\sigma_{cost<50}(\texttt{Catalog})) \bowtie \texttt{Suppliers}))$

(d) $(\pi_{sid}((\sigma_{colour=\text{“coral”}}(\texttt{Parts})) \bowtie (\sigma_{cost<200}(\texttt{Catalog})) \bowtie \texttt{Suppliers})) \cap$
$(\pi_{sid}((\sigma_{colour=\text{“charcoal”}}(\texttt{Parts})) \bowtie (\sigma_{cost<200}(\texttt{Catalog}) \bowtie \texttt{Suppliers}))$

(e) $\pi_{sname}((\pi_{sid,sname}((\sigma_{colour=\text{“teal”}}(\texttt{Parts})) \bowtie (\sigma_{cost<150}(\texttt{Catalog})) \bowtie \texttt{Suppliers})) \cap$
$(\pi_{sid,sname}((\sigma_{colour=\text{“eggshell white”}}(\texttt{Parts})) \bowtie (\sigma_{cost<100}(\texttt{Catalog})) \bowtie \texttt{Suppliers})))$

Question 4 (25 marks)

Consider a relation with schema $S(A,B,C,D)$ with functional dependencies $AB \to C$, $BC \to D$, $CD \to A$, and $AD \to B$. Answer each part below, and show all work (that is, show work towards computing closures).

(a) What are all the nontrivial FDs that follow from the functional dependencies? Ensure that all of your FDs have a single attribute on the right-hand side.

(b) What are all the keys of S?

(c) What are all superkeys for S that are not keys?

Question 5 (30 marks)

Consider a relation with schema $R(A,B,C,D,E)$ with FDs $AB \to C$, $DE \to C$, and $B \to D$. Answer each part below, and show all work.

(a) Indicate all BCNF violations. You should also consider all FDs inferred by the given set. You need not list violations for FDs having more than one attribute on the right-hand side.

(b) Decompose the relations as necessary into relations that are in BCNF.

Question 6 (30 marks)

Consider a relation `Equities(B,O,I,S,Q,D)`. The attributes may be thought of as (roughly) a stock broker, the broker's office, a stock investor, the stock itself, number of shares of the stock (quantity), and the yearly dividend produced by the stock[1]. The set of FDs for this relation are $S \to D$, $I \to B$, $IS \to Q$, and $B \to O$.

(a) What are all the keys for `Equities`?

(b) Verify that the given FDs are their own *minimal basis*. Some marks will be given for the quality of your answer.

(c) Use the 3NF synthesis algorithm to find a lossless-join, dependency-preserving decomposition of `Equities` into 3NF relations. Are any of the resulting relations not in BCNF?

Question 7 (30 marks)

Consider a relation with schema $T(A,B,C,D,E)$ with multi-valued dependencies $A \twoheadrightarrow B$ and $AB \twoheadrightarrow C$ and FDs $A \to D$ and $AB \to E$.

(a) Find all 4NF violations.

(b) Decompose the relation into a collection of relation schemas in 4NF.

Question 8 (15 marks)

Suppose we have a relation schema $R(A,B,C)$ with functional dependency $A \to B$. Now consider that we go ahead and decompose this into $S(A,B)$ and $T(B,C)$. Provide an example of a relation instance for R where the projection onto S and T and subsequent rejoining (as described in the course) does *not* yield the same relation instance. Put differently, $\pi_{A,B}(R) \bowtie \pi_{B,C}(R) \neq R$.

[1] Lucky if you can get it these days.