BMEG3120: Midterm Exam (Fall 2013)

Please write all your solutions in the answer book.

All the following questions are based on the tables below:

- **author** (aid, aname): This represents a table with name *author* whose attributes are as shown in the brackets. The underlined is the candidate key. Each tuple represents an author, whose id and name are given by *aid* and *aname*, respectively.

- **book** (bid, title, category): Each tuple represents a book. The attribute *category* describes the genre of the book (e.g., novel, sci-fi, science, music, ...).

- **student** (sid, sname, dept): Each tuple represents a student. The attributes’ meanings should be self-explanatory.

- **write** (aid, bid): A tuple means that book *bid* was written by author *aid*.

- **borrow** (sid, bid, checkout-time, return-time): A tuple means that student *sid* checked out book *bid* at *checkout-time*, and returned it at *return-time*.

All attributes are strings, except *checkout-time* and *return-time*, which are integers. A smaller *checkout-time* represents an earlier timestamp (same for *return-time*).

**Problem 1 (50%).** Give relational algebra queries for the tasks below:

1. (12%) Find the titles of all the books that the student with *sid* = “s100” has ever borrowed.

2. (12%) Find the titles of all the books that have never been borrowed by any student.

3. (14%) Find the title of the book that the student with *sid* = “s100” has checked out most recently. If the student has never borrowed any books, return an empty table (whose schema is up to you).

4. (12%) Find the names of all students that have borrowed all the books written by the author with *aid* = “a100”.

**Solutions.**

1. \( \Pi_{\text{title}} (\text{book} \bowtie \sigma_{\text{sid} = "s100"} (\text{borrow})) \)

2. \( \Pi_{\text{title}} (\text{book} \bowtie (\Pi_{\text{bid}} (\text{book}) - \Pi_{\text{bid}} (\text{borrow}))) \)

3. \( T_1 \leftarrow \sigma_{\text{sid} = "s100"} (\text{borrow}) \)
   \( T_2 \leftarrow T_1 \)
   \( T_3 \leftarrow \Pi_{T_1.\text{bid}} (\sigma_{T_1.\text{checkout-time} < T_2.\text{checkout-time}} (T_1 \times T_2)) \)
   \( T_4 \leftarrow \Pi_{\text{bid}} (T_1) - T_3 \)
   \( \Pi_{\text{title}} (T_4 \bowtie \text{book}) \)

4. \( T_1 \leftarrow \Pi_{\text{bid}} (\sigma_{\text{aid} = "a100"} (\text{write})) \)
   \( T_2 \leftarrow \Pi_{\text{sid, bid}} (\text{borrow}) \)
   \( \Pi_{\text{sname}} ((T_2 \div T_1) \bowtie \text{student}) \)

**Problem 2 (50%).** Give SQL queries for the tasks below:
1. (10%) Find the titles of all the books that have ever been borrowed by bme students (i.e., dept = ‘bme’).

2. (10%) Find the number of distinct students that have ever borrowed the book with bid = ‘b100’.

3. (10%) Find the titles of all the books that have ever borrowed by students from at least 10 distinct departments.

4. (10%) Let us define the borrow volume of a student as the number of distinct books s/he has ever borrowed. For each department, display its name (i.e., dept), and the largest borrow volume of its students.

5. (10%) Find the titles of the 10 books (not necessarily distinct) most recently borrowed by the student with sid = ‘s100’. If the student has borrowed less than 10 books, return the titles of all of them.

Solutions.

1. select title
   from book, borrow, student
   where book.bid = borrow.bid and borrow.sid = student.sid
   and dept = ‘bme’

2. select count(distinct sid)
   from borrow
   where bid = ‘b100’

3. select title
   from book, borrow, student
   where book.bid = borrow.bid and borrow.sid = student.sid
   group by book.bid, title
   having count (distinct dept) >= 10

4. select dept, max(vol)
   from (select dept, count (distinct bid) as vol
       from student, borrow
       where student.sid = borrow.sid
       group by student.sid, dept)
   group by dept

5. select title
   from book, borrow bor1, borrow bor2
   where book.bid = bor1.bid and bor1.sid = ‘s100’ and bor2.bid = ‘s100’
   and bor1.checkout-time <= bor2.checkout-time
   group by bor1.bid, title
   having count(*) <= 10