CSE 344 Midterm

Friday, February 8, 2013, 9:30-10:20

Name: _____

Question	Points	Score
1	60	
2	30	
3	10	
Total:	100	

- This exam is open book and open notes but NO laptops or other portable devices.
- You have 50 minutes; budget time carefully.
- Please read all questions carefully before answering them.
- Some questions are easier, others harder. Plan to answer all questions, do not get stuck on one question. If you have no idea how to answer a question, write your thoughts about the question for partial credit.
- Good luck!

1 SQL

1. (60 points)

A search engine company maintains a database with the following schema:

```
QueryLog(uid,qid,word)
User(uid, name, language)
Dictionary(word, language)
```

`QueryLog` is the archive of all keyword queries issued by the users; `User` is the set of registered users; `Dictionary` stores some common words in several languages. Note that one word may occur in more than one language.

To illustrate, we consider the following search queries:

```
Joe:      valentine day
Jaque:    day trip
Joe:      sidereal day
Jim:      day
```

and the following small database:

`QueryLog:`

uid	qid	word
u1	q1	valentine
u1	q1	day
u2	q2	day
u2	q2	trip
u1	q3	sidereal
u1	q3	day
u3	q4	day

`User:`

uid	name	language
u1	Joe	English
u2	Jaque	French
u3	Jim	English

`Dictionary:`

word	language
valentine	Latin
valentine	English
day	English
trip	English
sidereal	Latin
cosmos	Greek

Solution: To test all queries in this question, first run the following in sqlite:

```
.header on
.mode columns
create table QueryLog(uid int, qid int, word text);
create table User(uid int, name text, language text);
create table Dictionary(word text, language text);

insert into QueryLog values(1,1,'valentine');
insert into QueryLog values(1,1,'day');
insert into QueryLog values(2,2,'day');
insert into QueryLog values(2,2,'trip');
insert into QueryLog values(1,3,'sidereal');
```

```
insert into QueryLog values(1,3,'day');
insert into QueryLog values(3,4,'day');

insert into User values(1,'Joe','English');
insert into User values(2,'Jaque','French');
insert into User values(3,'Jim','English');

insert into Dictionary values('valentine','Latin');
insert into Dictionary values('valentine','English');
insert into Dictionary values('day','English');
insert into Dictionary values('trip','English');
insert into Dictionary values('trip','English');
insert into Dictionary values('sidereal','Latin');
insert into Dictionary values('cosmos','Greek');
```

```
QueryLog(uid,qid,word)
User(uid,name, language)
Dictionary(word, language)
```

(a) (15 points) Write a SQL query that returns the top 10 most common queried words, in decreasing order of their frequency. For our small example, the query would return:

day	4
sidereal	1
trip	1
valentine	1

Recall that you can limit the number of tuples returned using `limit`, for example:

```
select *
from T
limit 20
```

returns only 20 answers.

Solution:

```
select word, count(*)
from QueryLog
group by word
order by count(*) desc
limit 10;
```

```
QueryLog(uid,qid,word)
User(uid,name, language)
Dictionary(word, language)
```

(b) (15 points) Write a SQL query that returns all languages that were never used in a query. In our small example, your query would return `Greek`, because no user asked for any word in `Greek`.

Solution:

```
select distinct x.language
from Dictionary x
where not exists
     (select *
      from QueryLog y, Dictionary z
      where y.word = z. word and z.language = x.language);
```

```
QueryLog(uid,qid,word)
User(uid,name, language)
Dictionary(word, language)
```

(c) (15 points) You want to identify users who speak a foreign language. We assume that a user speaks a language L if she issues at least one query Q where all words are in L; if L is different from the user's native language (stored in `Users`) then we assume that she speaks the foreign language L. Write a query that returns all users that speak a foreign language. Your query should return the `uid`, the user name, and the foreign language.

For example, in our toy database your query should return `Jaque`, because he issued the query `day trip` where all words are in `English`; you should not return `Joe`: for example in his query `sidereal day`, while the first word is in Latin, the second is only in his native `English`.

Solution: Suggestion: write it first in the Relational Calculus:

$$\begin{aligned} q(uid, n, l) = &\exists q \exists w \exists lu[\texttt{QueryLog}(uid, q, w) \wedge \texttt{User}(uid, n, lu) \wedge \texttt{Dictionary}(w, l) \\ &\quad /* \text{ there is a query } q \text{ that mentions a word } w \text{ in some language } l \ */ \\ &\wedge l \neq lu \quad /* \text{ other than the user's language } */ \\ &\wedge \forall w_1(\texttt{QueryLog}(uid, q, w_1) \Rightarrow \texttt{Dictionary}(w_1, l))] \\ &\quad /* \text{ and all other words } w_1 \text{ in that query are in the language } l \ */ \end{aligned}$$

Note: *all* words in the query q are in the langauge l, and that we return l.

Datalog:

$$\begin{aligned} \texttt{queryHasSomeWordNotInL}(uid, q, l) = &\texttt{QueryLog}(uid, q, w_1), \neg\texttt{Dictionary}(w_1, l) \\ q(uid, n, l) = &\texttt{QueryLog}(uid, q, w), \texttt{User}(uid, n, lu), \texttt{Dictionary}(w, l), \\ &(l \neq lu), \neg\texttt{queryHasSomeWordNotInL}(uid, q, l) \end{aligned}$$

Finally, SQL. You can also write SQL directly.

```
select distinct x.uid, x.name, z.language
from User x, QueryLog y, Dictionary z  -- y defines the query Q
                                       -- z defines the language L
where x.uid = y.uid and y.word = z.word and x.language != z.language
  and not exists  -- check that ALL words in Q are in the language L
        (select *
         from QueryLog y1        -- is there a word NOT in L?
         where y.uid = y1.uid and y.qid = y1.qid
                                 -- same user, same query
           and not exists
                     (select *
                      from Dictionary z1
                      where z1.word = y1.word
                        and z1.language = z.language));
```

Very few people answered correctly, or almost correctly. A very small number tried to write the relational calculus first, and made some clear partial progress: I gave partial credit for that. Otherwise, I did not give partial credit for queries that made no sense to me.

(d) (10 points) The company monitors some users, and some keywords on a regular basis. That is, the company frequently runs queries of the following kind (where the valuess "Joe" and "valentine" are replaced with different constants)

```
QueryType1:
  select y.qid, y.word
  from User x, QueryLog y
  where x.uid = y.uid and x.name = 'Joe'
  order by y.qid, y.word;

QueryType2:
  select x.uid, x.name
  from User x, QueryLog y
  where x.uid = y.uid and y.word = 'valentine';
```

To speedup queries like these (where `Joe` and `valentine` are replaced with various constants), the database administrator considers creating the following indexes:

```
create index QL1 on QueryLog(uid)
create index QL2 on QueryLog(word)
create index QL3 on QueryLog(uid,word)

create index U1 on User(uid)
create index U2 on User(name)
create index U3 on User(uid,name)
```

Help the database administrator choose which indexes to create, by filling in the table below. For each entry, indicate one of the following tree options:

OK: this index may speed up queries of this type.

Dominated by X: the index may speed up queries of this type, but the index X would be at least as good, so the DBA should always prefer X.

Bad: the index is never useful for queries of this type, the DBA should not even consider it.

Fill in with one of `OK`, `Dominated by X`, `Bad`:

	QueryType1
	`select y.qid, y.word`
	`from User x, QueryLog y`
	`where x.uid = y.uid and x.name = 'Joe'`
	`order by y.qid, y.word;`
		QueryType2
		`select x.uid, x.name`
		`from User x, QueryLog y`
		`where x.uid = y.uid and y.word = 'valentine';`

QL1 `QueryLog(uid)`		
QL2 `QueryLog(word)`		
QL3 `QueryLog(uid,word)`		
U1 `User(uid)`		
U2 `User(name)`		
U3 `User(uid,name)`		

Solution:

	QueryType1
	`select y.qid, y.word`
	`from User x, QueryLog y`
	`where x.uid = y.uid and x.name = 'Joe'`
	`order by y.qid, y.word;`
		QueryType2
		`select x.uid, x.name`
		`from User x, QueryLog y`
		`where x.uid = y.uid and y.word = '`

QL1 `QueryLog(uid)`	OK	Bad
QL2 `QueryLog(word)`	Bad	OK
QL3 `QueryLog(uid,word)`	Dominated by QL1	Bad
U1 `User(uid)`	Bad	OK
U2 `User(name)`	OK	Bad
U3 `User(uid,name)`	Bad	Dominated by U1

(e) Answer the questions below:

i. (1 point) Which of the following is *not* a database management system:
(a) Oracle
(b) SQL Server
(c) Excel
(d) SQLite
(e) Postgres

i. **(c)**

Answer (a), (b), (c), (d) or (e).

ii. (4 points) Joe Pythonson never took a course in databases, but he is a proficient python programmer. For his job, he needs to develop an address book application, which stores names, phone numbers, emails, and addresses. Joe plans to develop it entirely in python, without using any database management system. You think that's a terrible idea, and try to convince Joe to use a database system like SQL Server or postgres. How would you answer to Joe's arguments?

(a) Joe: "I can implement the access procedure to the phone book very efficiently! I know splay-trees very well, they are efficient and I can implement them quickly". Your answer:
1. "Splay-trees do not support joins".
2. "You need to make splay trees persistent, and extend them with concurrent access: to implement them you will need much more time than you think".
3. "Splay trees are copyrighted, and you cannot use them in your commercial application"

ii. **2**

1, 2, or 3?

(b) Joe: "If I develop everything in python then the entire address book is in a single process. Thus, my application will run faster than, say, using SQL Server, which is a client server configuration and requires a network connection for every single user request". Your answer:

1. "True, but: the client-server configuration has the advantage of supporting simultaneous access by multiple users. If you program in python, then you have to implement multi users access yourself, and this requires a lot of work".
2. "False: the client-server configuration will run queries much more efficiently than the single process implementation because the database system optimizes the queries before running them."
3. "True, but: the client-server configuration can scale to much larger datasets, because the data is in a different process."

ii. **1**

1, 2, or 3?

(c) Joe: "I have just invented a new and amazing compression method for email addresses (for which I expect to receive the Turing Award). Using this specialized email compression technique I can make the email lookup function run 10^6 times faster than any database system, crushing my competitors". Your answer:

1. "You don't need to give up on a database management system: get the source code of an open source database management system, like postgres, implement your amazing email compression technique, recompile it, and still use your specialized method to crush the competition".
2. "Users will be turned away from your address book application when they learn that it is not powered by a database management system, even with your ridiculously fast lookup".
3. "This only speeds up access to email addresses, while all other accesses will be have the same speed; users won't notice much difference, while you will put a lot of effort reimplementing much of the functionality offered by a database management system."

ii. **3**

1, 2, or 3?

2 Relational Algebra, Datalog, and Relational Calculus

2. (30 points)

Consider the following database schema:

```
Person(name)
Friend(name1, name2)
```

`Person` contains all persons in the database, while `Friend` contains all friendship relationships.

Solution: Test the solutions using the following database:

```
create table Person(name text);
create table Friend(name1,name2);

insert into Person values('Alice');
insert into Person values('Bob');
insert into Person values('Carol');

insert into Friend values('Alice','Bob');
insert into Friend values('Alice','Carol');
insert into Friend values('Bob','Carol');
insert into Friend values('Carol','Alice');
```

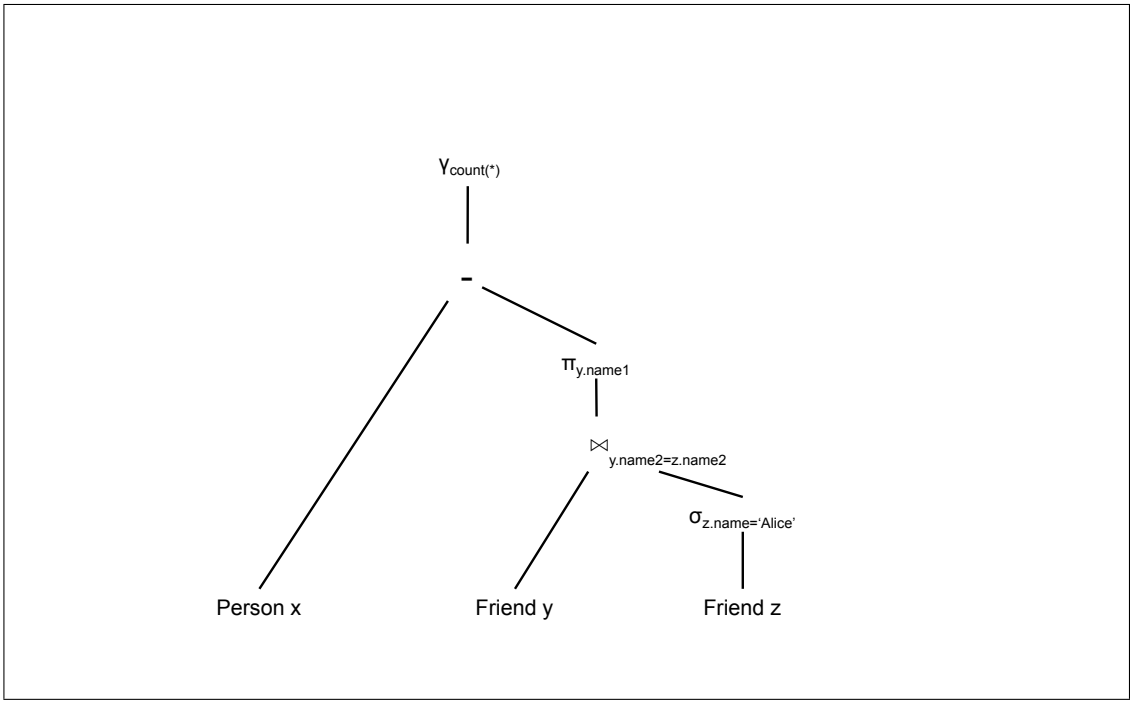
(a) (10 points) The SQL query below counts how many persons have no friends in common with Alice:

```
select count(*)
from Person x
where not exists
       (select *
        from Friend y, Friend z
        where x.name =y.name1
          and z.name1='Alice'
          and z.name2=y.name2);
```

Write a relational algebra expression that is equivalent to this SQL query. Write your answer as query plan (i.e. a tree).

Solution:

$$\gamma_{\texttt{count(*)}}(\texttt{Person} - \pi_{\texttt{y.name1}}(\texttt{Friend y} \bowtie \sigma_{\texttt{z.name1='Alice'}}\texttt{Friend z}))$$


γcount(*)
-
πy.name1
⋈
y.name2=z.name2
σz.name='Alice'
Person x
Friend y
Friend z

```
Person(name)
Friend(name1, name2)
```

(b) (10 points) Write a query in the relational calculus that finds all persons who are friends with all of Alice's friends.

Solution:

$$q(x) = \texttt{Person}(x) \wedge \forall y.\texttt{Friend}(\texttt{'Alice'}, y) \Rightarrow \texttt{Friend}(x, y)$$

(c) (10 points) Write a query in datalog with negation that finds all persons who are friends with all of Alice's friends.

Solution:

```
notAnswer(x) :- Person(x),Friend('Alice',y),not Friend(x,y)
Answer(x)    :- Person(x), not notAnswer(x)
```

3 XML and XPath

3. (10 points)

Consider the following XML document:

```
<persons>
 <person>
    <name> Alice </name>
    <friend>Bob</friend>
    <friend>Carol</friend>
 </person>
 <person>
    <name> Bob </name>
    <friend>Carol</friend>
 </person>
 <person>
    <name>Carol</name>
    <enemy>Alice</enemy>
 </person>
<persons>
```

(a) (5 points) Draw the tree representation of the XML document.

Solution: Straightforward.

(b) (5 points) Represent the same data in relational format. Show the tables, including the table names, their attributes, and their values (tuples).

Solution:

Person:

Name
Alice
Bob
Carol

Friend:

Name1	Name2
Alice	Bob
Alice	Carol
Bob	Carol

Enemy:

Name1	Name2
Carol	Alice