CMSC 661 – FINAL EXAMINATION – 12/18/95

This exam is closed book. Please write your name on the first page of the exam. You have 120 minutes to do all of the questions whose points sum to 130.

Thought for the day: "The really efficient laborer will be found not to crowd his day with work, but will saunter to his task surrounded by a wide halo of ease and leisure." - Henry David Thoreau

1 Understanding Relational Operators (10 points)

Assume that r and s are relations such that $r \subseteq s$ (i.e., r is a subset of s). Simplify the following expressions, i.e. give an equivalent expression with fewer operators.

1. $r \cup s$
2. $r \bowtie s$ (Natural Join)
3. $\sigma_{A=a}(r) - s$
4. $\Pi_X(r) \cap \Pi_X(s)$

2 Functional dependancies and normal forms (10 points)

A relation has three fields, A,B,C, and D, where AB is the only key. What is the most restrictive normal form (from 1st, 2nd, 3rd and BCNF) that characterizes the relation under the following conditions.

1. A,B,C, and D are each functionally dependent on AB?
2. A,B,C, and D are each functionally dependent on AB, while D is functionally dependent on C?
3. A,B,C, and D are each functionally dependent on AB, while D is functionally dependent on B?
4. A,B,C, and D are functionally dependent on AB, while B is functionally dependent on C?

3 Normalization (20)

Suppose we have a database for university enrollments consisting of the following attributes: S (student), M (major), C (class), I (instructor), O (office of instructor), G (grade student received in class), with the following functional dependencies: $S \longrightarrow M$, $C \longrightarrow I$, $I \longrightarrow O$, and $SC \longrightarrow G$.

1. (5 points) Find the candidate key(s) of the relation scheme $R = SMCIOG$.

2. (5 points) Find a lossless-join decomposition of R into Boyce-Codd normal form relations.

3. (5 points) Consider the decomposition $CSGM$ and CIO. Is this a BCNF decomposition? 3NF? 2NF?

4. (5 points) Does the decomposition into $CSGM$ and CIO have lossless join?

4 Transactions and Serializability (10 points)

An execution history is considered to be correct if and only if it is *serializable* - i.e., if and only if it produces the same result of some serial execution of those same transactions for arbitrary input. Consider the following transactions and their execution history H in which $R_i(x)$ and $W_i(x)$ represent a read and a write on record x, respectively. Is this history serializable? If so, show a serial history to which is it equivalent.

$$H: \quad R_1(z), R_2(x), R_3(y), W_2(x), R_3(x), R_1(x), \quad R_4(w), W_3(y), W_1(z), R_4(z), W_4(z), R_5(w), W_5(w)$$

$$\begin{aligned}
T_1 &: R_1(z), R_1(x), W_1(z) \\
T_2 &: R_2(x), W_2(x) \\
T_3 &: R_3(y), R_3(x), W_3(y) \\
T_4 &: R_4(w), R_4(z), W_4(z) \\
T_5 &: R_5(w), W_5(w)
\end{aligned}$$

5 Transaction Atomicity (10 points)

What does it mean for a transaction to be *atomic*?

6 Locking in distributed databases (15 points)

A colleague proposes a locking scheme for a distributed database with the following rules. In order to get a logical read lock on an item for which there are n copies a transaction must get local locks on j of the copies. In order to get a logical write lock on an item with n copies, a transaction must get local locks on k copies. Show at the following two constraints must hold in order for this scheme to work $j + k \leq n$ and $k \geq n/2$.

Several of the following problems ask you to consider the *AUTO Database* which encodes the following relations representing people (identified by their social security numbers (SSNs)), cars (identified by license numbers), ownership of cars, and the issuance of speeding tickets to people (identified by a unique citation number).

```
CREATE TABLE PERSON
 ( SSN     INTEGER NOT NULL,
   NAME    CHAR(40),
   STREET  CHAR(40),
   CITY    CHAR(40),
   STATE   CHAR(2),
   ZIP     INTEGER,
   PHONE   CHAR(12),
  PRIMARY KEY (SSN));
```

```
CREATE TABLE CAR
 ( LICENSE INTEGER NOT NULL,
   STATE   CHAR(2) NOT NULL,
   MAKE    CHAR(10),
   MODEL   CHAR(10),
   YEAR    INTEGER,
   PRIMARY KEY (STATE, LICENSE));
```

```
CREATE TABLE OWNS
 ( SSN     INTEGER NOT NULL,
   STATE   CHAR(2) NOT NULL,
   LICENSE INTEGER NOT NULL,
   PRIMARY KEY (SSN),
  FOREIGN KEY (SSN) REFERENCES PERSON,
  FOREIGN KEY (STATE,LICENSE) REFERENCES CAR);
```

```
CREATE TABLE TICKET
 ( CITATIONNUMBER INTEGER NOT NULL,
   LICENSE      INTEGER,
   STATE        CHAR(2),
   DATE         DATE,
   FOREIGN KEY (STATE,LICENSE) REFERENCES CAR,
   PRIMARY KEY CITATIONNUMBER);
```

7 Recognizing Queries in SQL (15 points)

Restate each of the following SQL queries in English.

1.
```
SELECT Name
FROM Person, Owns, Car
WHERE person.SSN = own.SSN
  AND owns.License = car.License
  AND car.Make = 'Toyota'
  AND car.Year = 1988
  AND person.state <> car.state;
```

2.
```
SELECT Name, Address
FROM Person p
WHERE NOT EXISTS (
  SELECT *
  FROM Car c, Owns o
  WHERE p.SSN = o.SSN
    AND o.License = c.License
    AND  c.Make <> 'Toyota');
```

3.
```
SELECT Name
FROM Person
WHERE EXISTS (
    SELECT *
    FROM Owns o1, Owns o2
    WHERE person.SSN = o1.SSN
      AND person.SSN = o2.SSN
      AND o1.license <> o2.license
      AND o1.state <> o2.state);;
```

8 Writing SQL Queries (15 points)

Using the same tables, write the following query in SQL.

1. Print the license numbers of red 1995 Honda accords that were ever issued speeding tickets.

2. Print the name and address of the person who has received the most number of speeding tickets.

3. Print the names and phone numbers of all people and the number of speeding tickets they have received.

9 Views (15 points)

Give an SQL expression that would define a view PHONE_LIST which is a table of people's names and their phone numbers. State whether or not this view updateable and, if you believe it is not, explain why it is not.

10 Embedded SQL (10 points)

(a) Give two advantages of *embedded SQL* over accessing a database through a set of special library routines. (b) Why does embedded SQL introduce the "cursor" mechanism.