NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2016-2017

CZ2007 – INTRODUCTION TO DATABASES

Apr/May 2017 Time Allowed: 2 hours

INSTRUCTIONS

1. This paper contains 4 questions and comprises 6 pages.

2. Answer **ALL** questions.

3. This is a closed-book examination.

4. All questions carry equal marks.

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1. (a) Consider a database for a company, *Rebu*, which allows users to book taxis via a mobile app. The requirements of the database are as follows:

- Each user has an ID, a name, a gender, and a phone number. A user may make multiple taxi bookings via the *Rebu* app.

- Each booking has an ID, a pickup location, a dropoff location, a booking timestamp, and a price. Once the booking is made, it is sent to several drivers. If none of the drivers accepts the booking, then the booking becomes a failed booking. Otherwise, the booking becomes a successful booking and will be handled by the first driver that accepts the booking.

- Each driver has an ID, a name, a gender, a phone number, and a driver's licence.

- A driver may use different vehicles on different dates or time. For each booking handled by a driver, *Rebu* records the vehicle used to serve the trip. *Rebu* also records the starting and ending timestamps of each trip.

Question 1(a) continues on Page 2

- Each vehicle has a car plate number, a car model, and a number of seats.

- If a user is not satisfied with her trip, she may file a complaint about the trip. Each complaint has a timestamp and a text. Each complaint is handled by an employee of *Rebu*.

- Each employee of *Rebu* has an ID, a name, a gender, and a salary.

(i) Construct an ER diagram that captures the requirements as much as possible.

(10 marks)

(ii) Convert the ER diagram into a set of tables. Indicate the primary keys.

(4 marks)

(b) Consider a database that stores information about tennis players, tennis courts, and tennis matches, with the following schema:

PLAYER(PID, Name, Gender, DOB)
COURT(CID, Location, Type)
MATCH(MID, P1, P2, CID, Date, P1Wins)

PLAYER records information about tennis players. COURT records the ID and location of each tennis court, as well as its type (i.e., whether it is grass, hard, or clay). MATCH records the result of each match. In particular, MATCH.P1 and MATCH.P2 are foreign keys referencing PLAYER.PID, while MATCH.CID is a foreign key referencing COURT.CID. PLAYER.P1Wins is a Boolean attribute that takes value TRUE if player P1 wins the match.

Answer each of the following queries with relational algebra. You may use the following operators: σ (selection), Π (projection), $\cup$ (union), $\cap$ (intersection), $-$ (difference), γ (grouping and aggregation), δ (duplicate elimination), $\div$ (division), $:=$ (assignment), ρ (rename), $\bowtie$ (join), $\dot{\bowtie}_L$ (left outerjoin), $\dot{\bowtie}_R$ (right outerjoin), $\dot{\bowtie}$ (full outerjoin).

(i) Find the CIDs of tennis courts on which there have been at least 100 matches.

(2 marks)

Question 1(b) continues on Page 3

(ii) For each tennis player, list the number of matches that he/she has won.

(2 marks)

(iii) Find the tennis players who have never lost a match on grass courts.

(3 marks)

(iv) Find the tennis player who ranks the 100-th in terms of the number of matches that he/she has won. (Assume that no two players won the same number of matches.)

(4 marks)

2. Consider a relation R(A, B, C, D, E) with the following functional dependencies: AB→C, BD→E, BE→D, AD→B, E→CD, BD→C.

(a) Derive the key(s) of R, and verify whether R is in BCNF. If R is not in BCNF, apply an BCNF decomposition on R, and then verify whether your BCNF decomposition preserves all functional dependencies.

(13 marks)

(b) Verify whether R is in 3NF. If R is not in 3NF, apply a 3NF decomposition on R.

(12 marks)

3. (a) Suppose that Q1 and Q2 are union compatible SQL queries and that, for a particular database, the tuple `(420, Donald)` appears five times in the results of Q1, and three times in the results of Q2. For each of the following SQL queries, indicate how many times `(420, Donald)` will appear in the result, assuming that the queries are evaluated against the same database.

(i) Q1 **UNION** Q2

(ii) Q1 **INTERSECT** Q2

(iii) Q1 **EXCEPT ALL** Q2

(4 marks)

Question 3 continues on Page 4

(b) Rewrite the following SQL query so that it does not use a subquery.

```
SELECT    DISTINCT name
FROM      TEAMS t
WHERE     EXISTS (SELECT    *
                  FROM      PLAYERS p
                  WHERE     p.teamid = t.teamid
                  AND       p.numgoals > 5);
```

(5 marks)

(c) Consider the following database schema (primary key is underlined):

BOOKS(id, category, price, promoted)

Create a view called PromotionSummary which outputs 3 columns named category, minprice and maxprice containing the category name, minimum price of all promoted books and maximum price of all promoted books, respectively. A promoted book has its promoted attribute set to `True`.

(5 marks)

(d) Consider the following database schema (primary keys are underlined):

EMP(ssn, name, birthdate, street, city, dno, superssn, salary)
DEPT(dnum, dname, mgrssn, dname)
DEPENDENT(essn, depname, sex, bdate, relationship)

In the above relations, superssn, mgrssn, and essn are foreign keys pointing to ssn, and dno is a foreign key pointing to dnum.

Give an SQL expression for each of the following queries. Your solution should be only one SQL statement.

(i) Give a 50% pay-cut to the employee(s) with the highest salary.

(5 marks)

(ii) Find the names of employees who have no dependents.

(6 marks)

4. (a) Consider the following database schema (primary keys are underlined)

PRODUCT(model, maker)
PC(model, speed, ram, hd, price)
LAPTOP(model, speed, ram, hd, screen, price)
PRINTER(model, color, type, price)

A PRODUCT is either a PC, a LAPTOP or a PRINTER and must have a tuple in the corresponding table. There is a foreign key constraint on the model of PCs, Laptops and Printers referencing the primary key model of PRODUCT. You can assume that the maker attribute uniquely identifies the manufacturer of a Product. Assume that all of the non-key attributes allow NULL values.

Formulate the following integrity constraint as one or more SQL triggers:
For every PC, there must be a Product with the same model.

(9 marks)

(b) Consider the relation R(A, B) which currently has only one tuple (1, 0). Assume that the following trigger has already been created for the database.

```
CREATE TRIGGER Times2
AFTER UPDATE ON R
REFERENCING NEW ROW AS n
FOR EACH ROW
WHEN (n.B < 5)
BEGIN
        UPDATE R SET B=B*2
        WHERE A=n.A;
        INSERT INTO R VALUES(100, 0);
END
```

List all tuples in R after the following update statement is executed:

```
UPDATE R SET B=2 WHERE A=1
```

(4 marks)

Question 4 continues on Page 6

```
<Hogwarts>
    <Rooms>
      <Room name="The_Dungeon" nrSeats="34" />
      <Room name="The_Cabin" nrSeats="163" />
    </Rooms>
    <Teachers>
      <Teacher name="Snape" room="The_Dungeon" >
        <Title>Professor</Title>
      </Teacher>
      <Teacher name="Hagrid" room="The_Cabin" />
    </Teachers>
    <Courses>
      <Course name="Potioncraft" teacher="Snape"  nrStudents="28">
        <Class day="Monday" hour="10" />
      </Course>
      <Course name="Wild_Creatures" teacher="Hagrid">
        <Class day="Saturday" hour="13" />
        <Class day="Thursday" hour="7" />
      </Course>
    </Courses>
</Hogwarts>
```

Figure Q4c

(c) Draw the tree data model (used for XPath) of the XML document **hogwarts.xml** in Figure Q4c. Clearly identify different types of nodes in this data model.

(6 marks)

(d) Reconsider the **hogwarts.xml** in Figure Q4c. Write XPath expressions for the following queries posed on this document.

(i) Find all courses that have classes on Mondays.

(2 marks)

(ii) Find all rooms that are used on Mondays.

(4 marks)

END OF PAPER

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Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.