NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2017-2018

CZ2007– INTRODUCTION TO DATABASES

Nov/Dec 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.

---

1.   (a)   Consider a database that records information for real estates in Singapore. The requirements of the database are as follows:

- Each *building* has a building name, a street name, a block number, and a postal code. The postal code uniquely identifies the building.

- Each building has a number of *units*. Each unit has a floor number and a unit number. Within the same building, no two units have the same (floor number, unit number) combination.

- Each unit has zero or more *owners*. Each owner is identified by his/her IC number, and has a name, a gender, and a date of birth.

- A unit might be put on sale for a price (referred to as the *sales price*).

- When a unit is sold in a *transaction*, we record the *final price* of the unit, which could be different from the sales price.

- For each unit, we maintain all the past and current *transactions* that involve the unit. Each transaction has a unique ID, a date-time, and a *buyer*. In addition, a transaction may also have a *sell-side agent*, and/or a *buy-side agent*. Whenever an agent is involved in a transaction, the *commission* paid to the agent is recorded.

- Each buyer is identified by his/her IC number, and has a name, a gender, and a date of birth.

- Each agent is identified by his/her IC number, and has a name, a gender, a date of birth, and a license number.

- For each unit, we also maintain a *history* of its owners. Each history record has an ID, an owner, a period of ownership. The ID of a history record is unique among the records associated with the same unit. Note that an owner of a unit is not necessarily a buyer of the unit, since the unit might be given away by one owner to another without going through a transaction.

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

(9 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 product sales:

Product (PID, PName, Price, Category)
User (UID, UName, Age)
Transaction (TID, PID, UID)

Product records information about products. User records information about users. Transaction records which user buys which product. For any two transactions A and B in Transaction, if A's TID is larger than B's TID, then A occurs later than B, and vice versa.

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), $\bowtie_L$(left outerjoin), $\bowtie_R$(right outer join), $\bowtie$(full outer join).

(i)   For each product category, find the PID of the most expensive product in the category.

(4 marks)

(ii)   Find the UID of the user who bought the 100th 'iPhone 8'.

(4 marks)

(iii)   Find the UID of the users who have bought all products in the "phone" category but not all products in the "laptop" category.

(4 marks)

2.   Consider a relation R(A, B, C, D, E, F) with the following functional dependencies: D$\rightarrow$AE, BE$\rightarrow$CD, AD$\rightarrow$C, AC$\rightarrow$B, C$\rightarrow$A.

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

(14 marks)

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

(11 marks)

3.   Consider the following relational schema.

Reader (<u>RDNR</u>, Surname, Firstname, City, Birthdate)
Book (<u>ISBN</u>, Title, Author, NumberOfPages, PublicationYear, PublisherName)
Publisher (<u>PublisherName</u>, PublisherCity)
Category (<u>CategoryName</u>, <u>BelongsTo</u>)
Copy (<u>ISBN</u>, <u>CopyNumber</u>, Shelf, Position)
Loan (<u>ReaderNr</u>, <u>ISBN</u>, <u>Copy</u>, <u>ReturnDate</u>)
BookCategory (<u>ISBN</u>, <u>CategoryName</u>)

BelongsTo refers to which parent categories the current category belongs to. Each book has a specific ISBN, and many copies of a book might be available under the same ISBN. Each copy of a book is identified by its ISBN and its CopyNumber. A reader may borrow the same copy for multiple times, and each instance is recorded by its ReturnDate. All the parent categories that a book belongs to are stored in the table BookCategory.

3

(a)   Formulate the following queries in SQL.

(i)   Which books have more pages than twice the average number of pages in all books?

(5 marks)

(ii)   Which author has written the maximum number of books?

(5 marks)

(iii)   Which readers have borrowed at least one book (by ISBN, not copies) from the author "Philip S. Yu", but have not borrowed all the books (by ISBN, not copies) from the author "Philip S. Yu"?

(5 marks)

(iv)   What are the surnames of the readers from the city "New York"?

(5 marks)

(b)   Formulate in SQL the following modifications:
The reader "Andy Goh" borrows the copy with CopyNumber "4" of the book with ISBN "123456".

(5 marks)

4.   (a)   Consider the following schema of a database used by a hospital to record information about patients and wards.

Wards (number, numbed)
Patients (pid, name, year, gender)
PatientInWard (pid, wardNumber)
Tests (pid, testDate, testHour, temperature, heartrate)

The attribute numbed is the number of beds in that ward. The name, year of birth, and gender ('M' or 'F') of each patient are stored in the Patients relation. The ward to which each patient is assigned is stored in the relation PatientInWard. During their stay in hospital, patients will undergo routine tests. The date and hour of each occasion when these tests are performed on a patient are recorded, and for each of these tests the patient's temperature and heart rate are measured and recorded in the database. A patient will normally undergo these routine tests several times during his stay in the hospital.

The hospital has a policy that all patients of age at least 60 years, and all female patients must be given a bed. Write an assertion to check the following constraint.

The number of beds in a ward should be larger than or equal to the number of patients in that ward who are either female or born no later than 1957.

(5 marks)

(b)   Enforce AC→B for every insertion in the relation R (A, B, C, <u>D</u>, E) with an SQL trigger.

(5 marks)

(c)   Consider a "drinker" database with the following relations.

Drinker (<u>drinker</u>, age, address)
Like (<u>drinker</u>, <u>beer</u>)
Beer (<u>beer</u>, manufacturer)
Bar (<u>bar</u>, owner, address)
Frequent (<u>drinker</u>, bar)
Sell (<u>bar</u>, <u>beer</u>, price)

Table Frequent indicates which specific bar a drinker likes to visit.

Using SQL, create a view UnLuckyDrinker (drinker, bar), to record those drinkers who cannot find all the beers that he likes in a bar that he frequents.

(5 marks)

(d)   Consider the following XML DTD in Figure Q4d. Create a valid XML document that follows the rules of the above DTD. Your document must illustrate all the rules of the DTD.

(5 marks)

(e)   What will be the result of the following XPATH query on your XML documents from Question 4(d).

//Choice/@code

(5 marks)

```
<!DOCTYPE results [
<!ELEMENT results (Applicants, Choices)>
<!ELEMENT Applicants (Applicant*)>
<!ELEMENT Applicant EMPTY>
<!ATTLIST Applicant name CDATA #REQUIRED appNum ID #REQUIRED >
<!ELEMENT Choices (Choice*)>
<!ELEMENT Choice EMPTY>
<!ATTLIST Choice applicant IDREF #REQUIRED code CDATA #REQUIRED
choiceNum CDATA #REQUIRED meritScore CDATA #REQUIRED>
]>
```

Figure Q4d

END OF PAPER

CZ2007 INTRODUCTION TO DATABASES

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.