NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2015-2016

CZ2007 – INTRODUCTION TO DATABASES

CPE303 – DATABASE SYSTEMS

Nov/Dec 2015 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 university database with the following requirements:

- The university has three types of employees: academic staffs, research staffs, and administrative staffs. Each employee has a unique employee ID. For each employee, his/her name, date of birth, job title, and salary are recorded.
- Each employee belongs to a school of the university (e.g., School of Computer Engineering). Each school has a unique ID, a name, and an address. Each school also has a chair, who is an academic staff.
- Each academic staff has a certain number of projects. Each project has a unique ID, a title, a project period, a total fund amount, and a fund balance. Each project is led by exactly one academic staff, and is monitored by one administrative staff.
- Each research staff is supervised by an academic staff, and his/her salary is paid from a project of an academic staff (who is not necessarily his/her supervisor). When the project that supports a research staff ends, the research staff may move on to work on another project and get paid. To keep check of this, each time a research staff works for a project, the starting and ending dates of the research staff's participation in the project are recorded.

Note: Question 1 continues on page 2

- Each academic staff may submit various reimbursement claims to his/her school (e.g., for reimbursing the cost of a conference trip). Each claim has a claim amount, a description, and a submission date. Each request is either approved or rejected by the chair of the school. If a request involves a project (e.g., the grant used for reimbursement), then the information about the grant is recorded in the claim.

(i) Draw an ER diagram that captures the above requirements.

(10 marks)

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

(4 marks)

(b) Consider the following schema containing bank account information. Primary keys are underlined.

```
Customers(name, address)
Accounts(number, balance)
Account_Owners(name, number)
```

Express the following queries using **Relational Algebra** (RA). You may use the following operators:

- σ (selection), Π (projection), $\bowtie$ (join)
- $\cup$ (union), $\cap$ (intersection), $-$ (difference)
- δ (duplicate elimination), $:=$ (assignment), ρ (rename)
- γ (grouping and aggregation), $\div$ (division)
- $\overset{\circ}{\bowtie}_L$ (left outerjoin), $\overset{\circ}{\bowtie}_R$ (right outerjoin), $\overset{\circ}{\bowtie}$ (full outerjoin)

(i) Find the owner of the account with the highest balance.

(2 marks)

(ii) Find the customer(s) who does not have any account with balance greater than 0.

(4 marks)

(iii) Find the accounts with the lowest 100 balances among all accounts. Assume that no two accounts have the same balance.

(5 marks)

2. Consider a relation R(A, B, C, D, E, F) with the following Functional Dependencies (FDs).

$$C \rightarrow D, \quad DF \rightarrow A, \quad AD \rightarrow F, \quad CD \rightarrow B, \quad BCF \rightarrow A$$

(a) Verify whether R is in BCNF. If R is not in BCNF, apply a BCNF decomposition on R, and then verify whether your 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. Consider the following schema of a database used by a hospital to record information about patients and wards (primary keys are underlined):

```
Wards(number, numBeds)
Patients(pid, name, year, gender)
PatientInWard(pid, wardNumber)
Tests(pid, testDate, testHour, temperature, heartRate)
```

The attribute numBeds 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 their stay in hospital.

(a) Write an SQL query that finds the temperature and heart rate measured in each test carried out on patients born before 1971.

(4 marks)

(b) Write an **assertion** to check the following constraint: *The number of patients in a ward cannot exceed the number of beds in that ward.*

(6 marks)

Note: Question 3 continues on page 4

(c) Create a view `FreeBeds(ward, numBeds)` where `ward` is a ward number, and `numBeds` is the number of available beds in that ward.

(6 marks)

(d) If an attempt is made to insert a new row into the relation `PatientInWard`, and that ward is already full, then the patient should instead be assigned to a ward that has an available bed. If there are several wards with available beds, then the patient should be assigned to the one with the *lowest* ward number.

Using the view you have defined in Question **Q3(c)**, write a **trigger** using SQL 99 that implements the above policy.

(9 marks)

4. (a) Consider the following schema of a database used by a multi-national company to manage the information about its offices in different cities, and its employees (primary keys are underlined):

```
Offices(city, supplement)
Departments(city, dname, departmentHead)
Employees(empid, name, salary, dept, city)
```

The company has one office in each city, and several departments can be located at each office. Attribute `supplement` is the monthly salary supplement that each employee working at that office receives (e.g., employees at the Singapore office might receive a supplement of 1000 USD per month to cover higher living costs in Singapore). Attribute `dname` describes the department's function (e.g., 'sales' or 'personnel'). Attribute `departmentHead` is the employee identifier of the head of the department. Attribute `salary` is an employee's basic monthly salary. The total monthly salary for an employee can be calculated by adding the city supplement to the employee's basic monthly salary.

(i) Write an SQL query that finds the employee identifier, name and total monthly salary of each employee. The results should be sorted by employee name.

(4 marks)

Note: Question 4 continues on page 5

(ii) Write a **stored procedure** called `Merge` that *merges* two departments into one. This procedure should have four input parameters: `city1`, `dept1`, `city2`, `dept2`. All employees from the first department should be reassigned to the second department. The head of the merged department is selected based on which department was larger before merging. That is, if the first department was larger then the head of that department becomes the head of the merged department, otherwise the head of the second department becomes the head of the merged department.

(10 marks)

(b) Consider the following XML document.

```
<A a1="A1">
    <B b1="B1" b2="15">
        <C c1="red">first</C>
    </B>
    <B b1="B2">
        <C c1="green">second</C>
    </B>
    <B b1="B3" b2="25">
        <C c1="blue">third</C>
    </B>
    <B b1="B4" b2="35">
        <C c1="red">fourth</C>
    </B>
</A>
```

Consider the following XML DTD.

```
<!DOCTYPE A [
    <!ELEMENT A (B)>
    <!ELEMENT B (C)>
    <!ELEMENT C (#PCDATA)>
    <!ATTLIST A a1 CDATA #REQUIRED>
    <!ATTLIST B b1 CDATA #REQUIRED b2 CDATA #REQUIRED>
    <!ATTLIST C c1 CDATA #REQUIRED>
]>
```

(i) Give two reasons why the XML document shown above is not compatible with the above DTD.

(4 marks)

Note: Question 4 continues on page 6

(ii) State how the DTD should be modified so that it is compatible with the above XML document.

(3 marks)

(c) Show the results returned by each of the following XPath queries when executed on the XML document in Question **Q4(b)**:

(i) `/A/B[C/@c1="red"]`

(ii) `//B[attribute::b2>20]/C`

(4 marks)

END OF PAPER

CZ2007 INTRODUCTION TO DATABASES
CPE303 DATABASE SYSTEMS

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.