ECM2419

UNIVERSITY OF EXETER

COLLEGE OF ENGINEERING, MATHEMATICS AND PHYSICAL SCIENCES

COMPUTER SCIENCE

Examination, January 2020

Database Theory and Design

Module Leader: Dr Hongping Cai

Duration: TWO HOURS

Answer ALL questions.

The marks for this module are calculated from 70% of the percentage mark for this paper plus 30% of the percentage mark for associated coursework.

No electronic calculators of any sort are to be used during the course of this examination.

This is a CLOSED BOOK examination.

Question 1

(a) There are a number of important functions provided by the *database management system*. Describe *four* of them.

(8 marks)

(b) There are a number of *computer-based security mechanisms* for protecting the database from threats. List *four* of them.

(4 marks)

(c) What is *deadlock*? Which *three main methods* could we use to deal with deadlock?

(8 marks)

(d) (i) What does it mean that a schedule is *serializable*?

(2 marks)

(ii) Consider three transactions T_1, T_2 and T_3, and one schedule S given below. Draw the *precedence graphs* for this schedule, and state whether it is *serializable* or not.

T_1: $r_1(X)$; $r_1(Z)$; $w_1(X)$;

T_2: $r_2(Z)$; $r_2(Y)$; $w_2(Z)$; $w_2(Y)$;

T_3: $r_3(X)$; $r_3(Y)$; $w_3(Y)$;

S: $r_1(X)$; $r_2(Z)$; $r_3(X)$; $r_1(Z)$; $r_2(Y)$; $r_3(Y)$; $w_1(X)$; $w_2(Z)$; $w_2(Y)$; $w_3(Y)$;

Where $r_i(Z)$ and $w_i(Z)$ indicate a read and a write operation respectively by the i-th transaction on data item Z.

(7 marks)

(e) What are *checkpoints*? Why are they important in database recovery?

(5 marks)

(f) Desribe two desirable characteristics of a *distributed DBMS*.

(6 marks)

(Total 40 marks)

Question 2

(a) Motor vehicle branches manage driving tests and issue driving licenses.

- Any person who wants a driving license must first take a driving theory test at any Motor Vehicle Branch. Each person has a unique ID, name (first name and last name are recorded separately), date of birth and address recorded. Each branch has a unique name, address and one or two telephone numbers.
- If a person fails the theory test (recorded with the date, time and score), they can take the test again any time at any branch.
- Once a person passes the theory test, they are issued a *provisional* driving license with the issue date, expiry date and a unique license number.
- The person may take the practical test at any branch any time before the expiry date of the *provisional* driving license. Similar to the theory test, the practical test also has the date, time and score recorded.
- If the person passes the practical test, the branch issues a *full* driving license with recorded information similar to that of the *provisional* license. The only difference is that a *full* driving license also records the entitlement categories that specify what vehicles can be driven. For each category, a unique category ID and a description of the entitled vehicles are specified.

Draw an *entity-relationship diagram* (using UML notation) with *specialisation/generalisation* concepts for this motor vehicle management system as described above. Identify all entities, relationships, attributes (including primary keys) and multiplicity constraints.

(17 marks)

(b) Give an example of a *fan trap* in ER modelling.

(3 marks)

(c) Farmer Lucy owns a herd of dairy cows. In a spreadsheet she records the volume of milk produced each day by each of the cows. Each cow is required by law to have a unique ear tag number so that its ownership can be tracked over its whole life. The following table shows a small subset of her data, which is unnormalized.

CowName	EarTagRef	BirthDate	Date	MilkYield	Date	MilkYield	Date	MilkYield	Date	MilkYield	Date	MilkYield
Daisy	D201001	03/05/2010	01/10/2012	32	02/10/2012	34	03/10/2012	12	04/10/2012	38	05/10/2012	31
Ermintrude	D201002	12/05/2010	01/10/2012	28	02/10/2012	29	03/10/2012	30	04/10/2012	27	05/10/2012	28
Mabel	D201003	14/05/2010	03/10/2012	36	04/10/2012	38	05/10/2012	37	06/10/2012	38	07/10/2012	36

(i) What are the two main objectives of normalisation in database design?

(3 marks)

(ii) Briefly describe the three steps required to transform an unnormalized table into the *3rd normal form (3NF)*.

(3 marks)

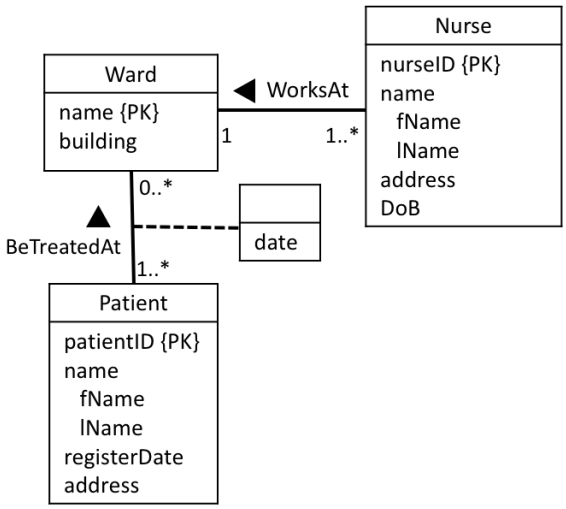
(iii) Transform the above table into relations in the *3rd Normal Form (3NF)* by using relational schemas (with primary keys underlined) rather than detailed tables.

(4 marks)

(Total 30 marks)

Question 3

(a) Consider the following entity-relationship diagram.



Transform the above *ER diagram into a relational model*, reporting primary keys and foreign keys.

(8 marks)

(b) Consider the following relations from a Police Traffic database.

Vehicle (vehicleID, make, model, colour, personID)

Person (personID, name, address, NIN, licenseNumber, expiryDate)

Fine (vehicleID, date, time, amount, offenceID)

Offense (offenceID, description, maximumFine)

The **Fine** relation records fines for traffic offences, while the **Offense** relation records different types of offenses that may be committed.

(i) Write the following queries in *relational algebra*. To shorten the expression, you may use initials letters in place of the full relation names, e.g., O stands for 'Offense'.

A) Find all the offenses whose maximum fine is more than £100. Display the description and maximum fine.

(3 marks)

B) List the date and amount of every fine charged to Floyd Pepper since 1 January 2019. (Note: The date is represented by '2019-01-01')

(4 marks)

(ii) Write the following queries in *SQL statements*.

A) Display the make and model of the vehicle with vehicleID 'RX63LDN'.

(3 marks)

B) Display the car registration number (vehicleID) for all cars which have accumulated more than £1,000 of fines.

(4 marks)

C) List the largest fine for each type of offense in London area, i.e., for which the person involved in has an address containing "London".

(5 marks)

D) Renew Floyd Pepper's driving license, with the new expiry data 2021-01-20. (Assume Floyd Pepper is a unique name in the database)

(3 marks)

(Total 30 marks)