Indian Institute of Technology Roorkee

Department of Computer Science and Engineering
End-semester Examination (Autumn 2024-25)
Course Name: Database Management System
Course Code: CSN-351
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Batch: CSE & Non-CSE
Duration: 3 Hours

Date: November 27, 2024
Full Marks: 100

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*(**Instructions:** There are two sections. Answer all the questions from each section.)*

Section - A. Relational Database Design and SQL [50 marks]

(1) Consider the following relational schema $R(A, B, C, D, E)$ and set of functional dependencies as: $\{AB \rightarrow E, D \rightarrow C\}$ [5+5]

i. List all superkey(s) for this relation. Which of these superkeys form a key (i.e., a minimal superkey) for this relation? Justify your answer in terms of functional dependencies and closures.

ii. Decompose R into BCNF. Show your work for partial credit. Your answer should consist of a list of table names and attributes and an indication of the keys in each table (underlined attributes).

(2) Consider a social network database, about people and their relationships. The database has two relations: *Person(pid, name)* and *Relationship(pid1, rel, pid2)*. [5+5] Here *Person.pid* is a key, and *Relationship.pid1* and *Relationship.pid2* are foreign keys; *rel* is a string representing the relation type, and can be friend or enemy. Note that the relationship is not necessarily symmetric: if *Alice* is friend with *Bob*, this does not imply that *Bob* is friend with *Alice*.

i. Write the SQL statements that define the relational schema for this database. Assume that *pid* are integers, and *name* and *rel* are character strings.

ii. Write a SQL query that computes, for each person, the total number of their friends. Your query should return results containing the *pid*, the *name*, and the *count*. Note that your query must return exactly one answer for every person in *Person*.

(3)

Consider the relations containing airline flight information in Figure 1, where the primary keys are underlined. Note that the Employees relation describes pilots and other kinds of employees as well; every pilot is certified for some aircraft (otherwise, he or she would not qualify as a pilot), and only pilots are certified to fly. Write the following queries in relational algebra, and SQL. Note that some of these queries may not be expressible in relational algebra ! For such queries, informally explain why they cannot be expressed. [5x2+5x4]

i. Find the *eids* of pilots certified for some Boeing aircraft.

ii. Find the total amount paid to employees as salaries

iii. Find the *names* of pilots certified for some Boeing aircraft.

iv. Find the *aids* of all aircraft that can be used on non-stop flights from Bonn to Madras.

v. Identify the flights that can be piloted by every pilot whose salary is more than $100,000.

vi. Find the names of pilots who can operate planes with a range greater than 3,000 miles but are not certified on any Boeing aircraft.

vii. Find the *eids* of employees who make the highest salary.

viii. Find the *eids* of employees who make the second highest salary.

ix. Find the *eids* of employees who are certified for the largest number of aircraft.

x. Find the *eids* of employees who are certified for exactly three aircraft.

```
Flights(fino: integer, from: string, to: string,
        distance: integer, departs: time, arrives: time)
Aircraft(aid: integer, aname: string, cruisingrange: integer)
Certified(eid: integer, aid: integer)
Employees(eid: integer, ename: string, salary: integer)
```

Figure 1: Employee database.

Section - B. Transaction Management [50 marks]

(1) Consider the snapshot of two transactions in Figure 2. Add lock and unlock instructions to transactions T_{31} and T_{32}, so that they observe the two-phase locking protocol. Can the execution of these transactions result in a deadlock? Justify your answer by illustrating a partial schedule. [5+5]

(2) i. List and explain the usefulness of ACID properties. List all possible sequence of states through which a transaction may pass through a state diagram. [10+2+4+4]

ii. Explain the distinction between: serial schedule and serializable schedule.

iii. Consider the precedence graph of Figure 3. Is the corresponding schedule conflict serializable? Explain your answer.

iv. State and justify the Thomas Write Rule

```
T31: read(A);
     read(B);
     if A = 0 then B := B + 1;
     write(B).

T32: read(B);
     read(A);
     if B = 0 then A := A + 1;
     write(A).
```

Figure 2: Snapshot of two transactions

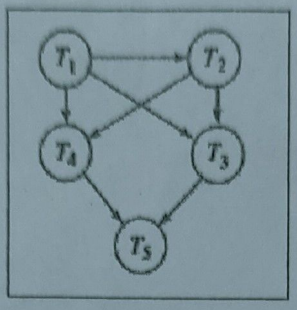

Figure 3: Precedence Graph

(3) i. What is the difference between blind write and dirty read?

ii. What are the necessary conditions for deadlock? How can deadlock be prevented? [4+8+2+4+2]

iii. Explain the purpose of wait-for graph.

iv. Define phases of 2PL protocol

v. How Strict time stamp protocol is different from Basic time stamp protocol?