COMSATS UNIVERSITY, ISLAMABAD
Department of Computer Science
Theory Midterm Examination, Fall-2021
SOLUTION

Course / Class: Database Systems - I (CSC371) / BCS, BSE IV **Date: November 15, 2021**
Instructors: Dr. Basit Raza, Qasim Malik **Time Allowed / Total Marks: 1.5 Hrs / 25**

1- **[CLO-C2]** In this question, you are provided a sample database. It contains three relations: **[1.5+1.5]**

Student(student_id, student_name) // student_id is the key
EnrolledIn(student_id, course_code) // (student_id, course_code) is the key
Course(course_code, course_instructor) // (course_code) is the key

You have also been provided instances of each of the above relations.

student_id	student_name
1234	Ahmad
4000	Ali
2000	Usman

student_id	course_code
1234	CS1500
1234	CS1200
1234	CS2001
4000	CS3010
4000	MA3000

course_code	course_instructor
CS1500	Dr. Basit
CS2001	Mr. Rashid
CS3010	Dr. Basit
CS2001	Mr. Yasir
MA3000	Mr. Qasim

A database application developer wrote relational algebra queries for a couple of needs over that database. Given below are the results of these queries. We have lost those queries somewhere. For each of the following resultant relations, now you are to think of a relational algebra expression that can produce the same result?

1a.

Student.student_id	student_name	EnrolledIn.student_id	course_code
1234	Ahmad	1234	CS1500
1234	Ahmad	1234	CS1200
1234	Ahmad	1234	CS2001
1234	Ahmad	4000	CS3010
1234	Ahmad	4000	MA3000

Solution: σ Student.student_id=1234 (Student $\times$ EnrolledIn)

1b.

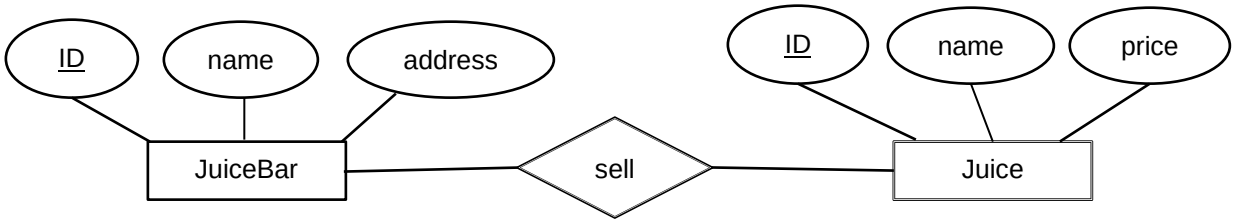
student_id	student_name	course_code	course_instructor
4000	Ali	CS3010	Dr. Basit
4000	Ali	MA3000	Mr. Qasim

Solution: σ student_id=4000 (Student $\bowtie$ EnrolledIn $\bowtie$ Course)

2- **[CLO-C3]** Suppose there are various juice bars, each selling variety of juices in a certain town. The town administration is interested in maintaining their data. As part of their price regulation policy, the town administration has decided that each type of juice will be sold at the same price. **[2]**

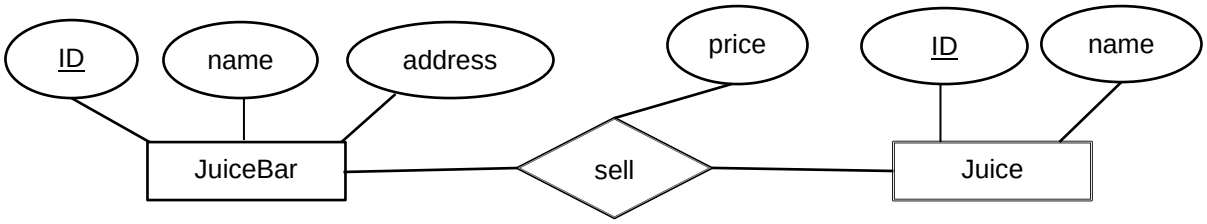
2a. Draw an Entity Relationship Diagram (ERD) for this simple scenario with two entity sets. (Assume attributes as per your-real world knowledge)

Solution:



2b. Suppose the town administration has relaxed the policy and allowed each juice bar to have its own prices for the juices they offer. How will the above ERD change now?

Solution:

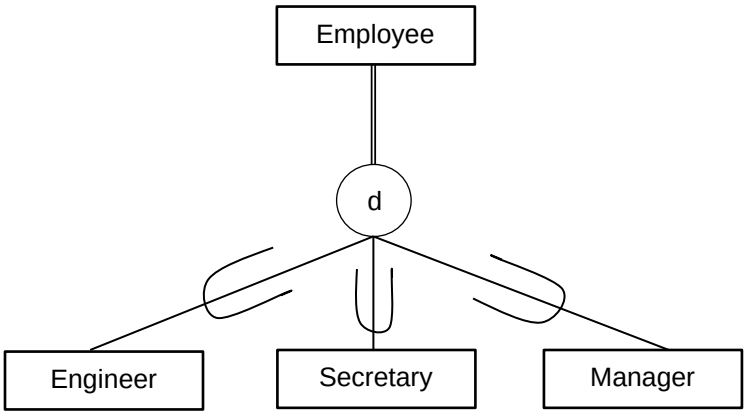


3- [CLO-C3] Suppose a company has several types of employees, with job types being engineer, secretary, and manager. Suppose, we want model the following data requirement:

An employee is always assigned a job type and does only one type of job.

Draw an Enhanced ERD modeling this requirement. **[2]**

Solution:



4- [CLO-C3] Consider the table below: **[2]**

A	**B**	**C**
a1	b1	c1
a1	b2	c2
a2	b3	c1
a2	b3	c2

For each of the functional dependencies (FDs) listed below, indicate whether it holds or not. If it holds, write OK. If it does not hold, indicate two tuples in the table above that violate the functional dependency. Refer to the tuples as 1,2,3,4; for example, you may say that a certain FD fails because of the tuples 3,4.

4a. B → A

Solution: OK

4b. AC → B

Solution: OK

4c. $A \rightarrow B$

Solution: It does not hold due to tuples 1,2

4d. $B \rightarrow C$

Solution: It does not hold due to tuples 3,4

5- [CLO-C3] Consider a relation R (A,B,C,D,E,F) with a following set of functional dependencies (FDs):

$$CDE \rightarrow B,\ ACD \rightarrow F,\ BEF \rightarrow C,\ B \rightarrow D$$

For each of the following set of attributes, check if they can form a key for R. Show all your steps. **[2]**

5a. ABE

Solution: Since $\{ABE\}^+ = \{A,B,E,D\} \neq$ All of the attributes, hence, it does not form a key

5b. ABCE

Solution: Since $\{ABCE\}^+ = \{A,B,C,E,D,F\}$ = All of the attributes, hence, it does form a key

5c. ADEF

Solution: Since $\{ADEF\}^+ = \{A,D,E,F\} \neq$ All of the attributes, hence, it does not form a key

5d. ABEF

Solution: Since $\{ABEF\}^+ = \{A,B,C,D,E,F\}$ = All of the attributes, hence, it does form a key

6- Consider a relation R (A,B,C,D). For the following sets of FDs, is R in Boyce-Codd Normal Form (BCNF)? Show your steps. **[3]**

$$AC \rightarrow D,\ D \rightarrow A,\ D \rightarrow C,\ D \rightarrow B$$

Solution: For a given set of FDs to be in BCNF, each of these FD's must satisfy the BCNF condition which is "If A→B then A is a key". In other words, the left-hand side of each of the FDs must be a key for R.
Let's pick the first FD first, and check if its left-hand side AC is the key. To find it out, let's find out the closure of AC i.e.
$\{AC\}^+ = \{A,C,D,B\}$
Since $\{AC\}^+$ contains all the attributes of R, i.e., the attributes AC functionally determines all the attributes of relation R, hence attributes AC form a key.
For the remaining FDs, D is at the left-hand side of every FD, so let's check if D is a key by finding its closure:
$\{D\}^+ = \{D,A,C,B\}$
Since $\{D\}^+$ contains all the attributes of R, i.e., the attribute D functionally determines all the attributes of relation R, hence the attribute D also forms a key.
Since for every given FD, its left-hand side is a key, therefore, for a given set of FDs, R is in BCNF.

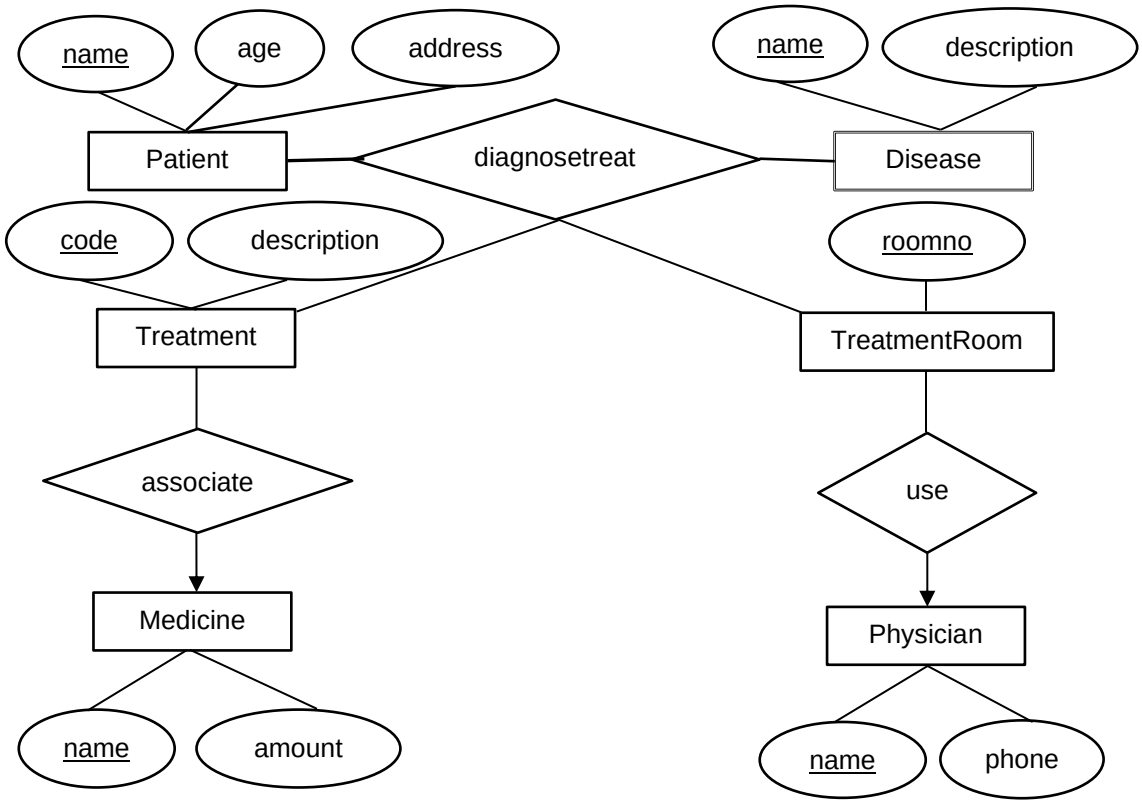
7- [CLO-C3] A small hospital wants to design a database to manage the data of patients, physicians, treatments done, and, prescribed medicines. Suppose they have provided the following requirements:

- patient names are unique. (In the sample data shown below, the first three rows correspond to the same patient)
- a patient may be diagnosed with many diseases
- for each disease, a patient is assigned a unique treatment room
- a treatment room is only used by one physician while a physician can use more than one treatment room
- a patient is given a single treatment for a certain disease

- a disease does not have a single treatment associated with it
- a treatment has only one medicine associated with it while many treatments can be based on the same medicine
- a medicine has always the same prescribed amount associated with it

7a. Draw an Entity-Relationship Diagram (ERD) that models the above set of data requirements. (Assume attributes as per your-real world knowledge) **[4]**

Solution:



7b. Map the ERD created in part 7a, to its corresponding relational schema. Specify all the primary key and foreign key constraints in the resultant schema. **[2]**

Solution:

- Patient (name, age, address)
- Disease (name, description)
- Physician (name, phone)
- TreatmentRoom (roomno, physicianname FK REFERENCES Physician(name))
- Medicine (name, amount)
- Treatment (code, description, medicinename FK REFERENCES Medicine(name))
- diagnosetreat (patientname FK REFERENCES Patient(name), diseasediagnosed FK REFERENCES Disease(name), treatmentroomno FK REFERENCES TreatmentRoom(roomno), treatmentcode FK REFERENCES Treatment (code))

7c. Assume that we want to design schema through decomposition and have identified the attributes from the above set of requirements and put them into a mega relation which looks like:
HospitalData (patientName, patientAge, patientAddress, physicianName, diseaseDiagnosed, treatmentRoom, treatmentCode, prescribedMedicine, prescribedAmount)
Here's the sample data provided by the hospital for better understanding of the requirements:

patientName	diseaseDiagnosed	patient Age	patientAddress	physicianName	treatment Room	treatment Code	prescribed Medicine	prescribed Amount
Ahmed Ali	Ulcer	48	I-9/1, Islamabad	Farooq Ali	Room10	UL100	a220	twice a day
Ahmed Ali	high blood pressure	48	I-9/1, Islamabad	M. Wasif	Room01	PP100	Betamicin	once a day
Ahmed Ali	high cholesterol	48	I-9/1, Islamabad	Bashir Khan	Room05	D700	NULL	NULL
Atif Khan	stomach ache	37	F-6/1, Islamabad	Farooq Ali	Room12	UL100	a220	twice a day
Atif Khan	head ache	37	F-6/1, Islamabad	Bashir Khan	Room07	PP100	Betamicin	once a day
Isma Ali	Ulcer	54	I-8/3, Islamabad	Lyba Ahmed	Room16	NN25	Amophilin	once a day

This schema is only in 1NF at the moment, and thus suffers from a number of problems. Provide examples of how insertion, deletion, and update anomalies can occur in this table. **[2]**

Solution:

Insertion: If we want to insert only a new physician, a new treatment or a new patient, they all require other insertions to be made in order to have consistent data (e.g., a new physician can be inserted only if s/he treats a patient); such supplementary insertions are neither necessary nor desirable.
Deletion: If we want to delete the physician *Lyba Ahmed* it will result in the deletion of the patient *Isma Ali* from the database too.
Modification: If we modify the address of the patient *Ahmed Ali*, we will have to update it in all the rows. If we forget it to propagate everywhere, the database will become inconsistent.

7d. Identify all functional dependencies that are expected to hold in the mega relation of part 7c, based on the requirements provided in the description at the start. **[3]**

Solution:

FD1: patientName $\rightarrow$ patientAge, patientAddress
FD2: patientName, diseaseDiagnosed $\rightarrow$ treatmentRoom, treatmentCode
FD3: treatmentRoom $\rightarrow$ physicianName
FD4: treatmentCode $\rightarrow$ prescribedMedicine, prescribedAmount
FD5: prescribedMedicine $\rightarrow$ prescribedAmount