Department of Computer Science, City University of Hong Kong

**CS3402 Database Systems**

**Assignment 1**

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Question A. [50 marks]

A database is being designed to manage the operations of a hospital:

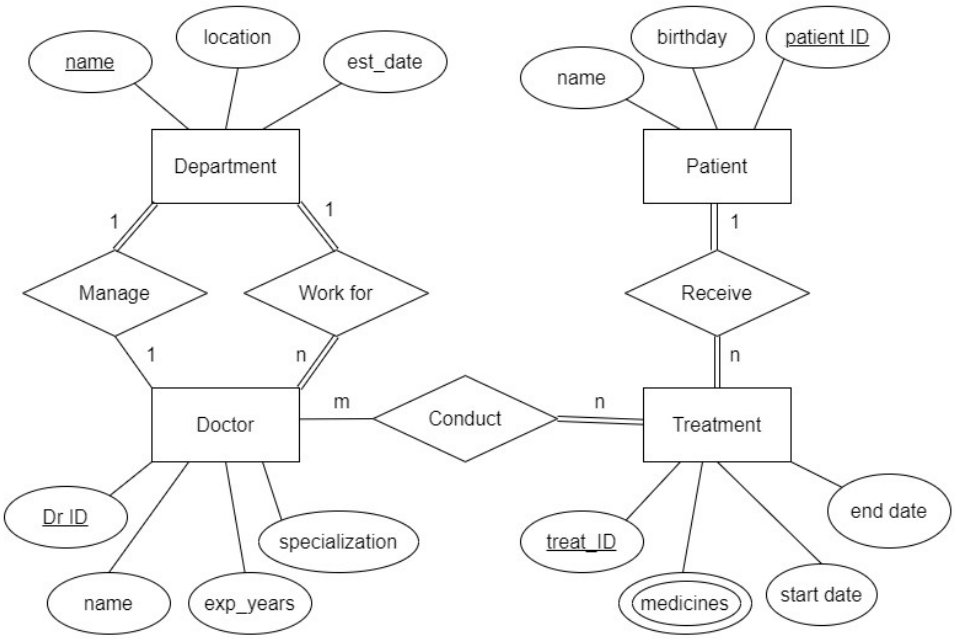
- The hospital has multiple departments, each of which has a unique name, a date of establishment, a location, and a set of doctors, with one of them being the head of the department.
- Each doctor works in only one department and has a unique ID number, a name, a specialization (such as Cardiology or Neurology), years of experience.
- Each patient has a unique ID number, a name, a date of birth.
- A patient comes to the hospital to receive one or more treatments.
- Each treatment has a unique treatment ID, a start date, an end date, associated with multiple prescribed medicines.
- Each treatment involves one patient and may involve one or more doctors to conduct it.
- Each doctor can conduct zero or multiple treatments.

1) Design an ER diagram for this application, stating any assumptions you make. However, the assumptions should not conflict with the description provided above, and no additional entities, attributes, or relationships should be introduced. [30 marks]

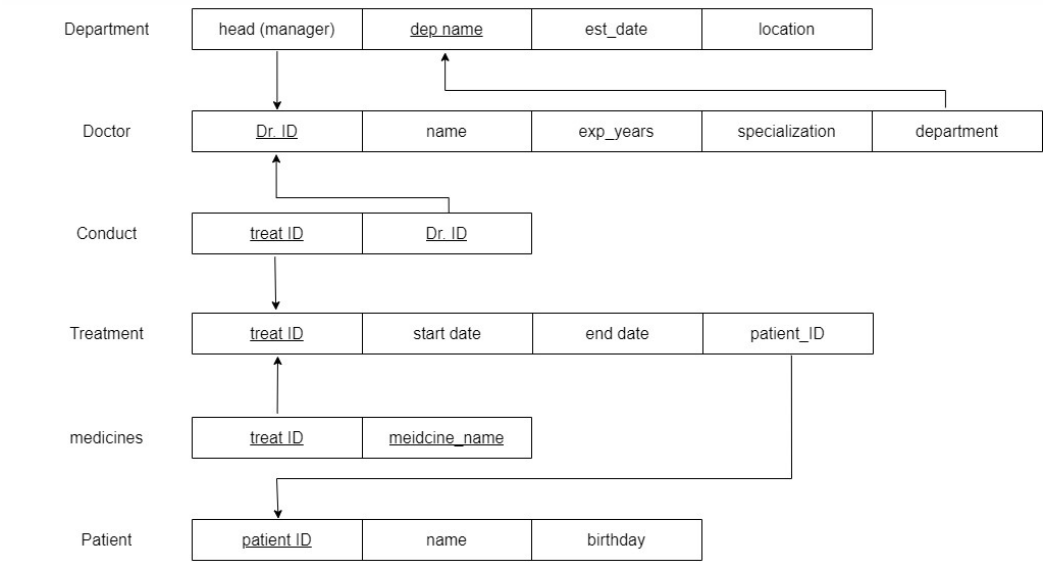
2) For your ER diagram given above, convert it into relational schema using the steps discussed in the lecture. For each relation (table) obtained, specify the name and its attributes, as well as its primary key and foreign keys. [20 marks]

Answer:

1) ER diagram: [30 marks]




2) ER → Relational model: [20 marks]



Question B. [50 marks]

Consider the relation R = {A, B, C, D, E, F, G, H, I, J} and the set of functional dependencies F = {{A, C}→{B, D}, {A, D}→{E}, {B, E}→{F}, {F}→{G, H}, {D, F}→{I, J}}.

(a) Proof {A, C}→{E, J} holds by using inference rules. [10 marks]

(b) Whether {A, D, F} is a super key? Whether {A, D, F} is a candidate key? Why? [10 marks]

(c) Whether {A, B, C} is a super key? Whether {A, B, C} is a candidate key? Why? [10 marks]

(d) Decompose R into 2NF. [10 marks]

(e) Decompose R into BCNF. [10 marks]

(e) [10 marks]

R does not satisfy BCNF, because the lefthand side of these functional dependencies {A, D}→{E}, {B, E}→{F}, {F}→{G, H}, {D, F}→{I, J} are not super keys, which violates the BCNF. Thus, we can decompose R into the following relations to achieve BCNF:

R1 = {A, C, B, D}
R2 = {A, D, E}
R3 = {B, E, F}
R4 = {F, G, H}
R5 = {D, F, I, J}

Answer:

(a) [10 marks]

1 {A, C}→{B, D} (given)
2 {A, C}→{B}, {A, C}→{D} (decomposition, 1)
3 {A, D}→{E} (given)
4 {A, C}→{E} (pseudotransitive, 2&3)
5 {A, C}→{B, E} (union, 2&4)
6 {B, E}→{F} (given)
7 {A, C}→{F} (transitive, 5&6)
8 {A, C}→{D, F} (union, 2&7)
9 {D, F}→{I, J} (given)
10 {D, F}→{J} (decomposition, 9)
11 {A, C}→{J} (transitive, 8&10)
12 {A, C}→{E, J} (union, 4&11)

(b) [10 marks]

{A, D, F}+ = {A, D, E, F, G, H, I, J}. It is not a super key. Thus, it is not a candidate key.

(c) [10 marks]

{A, B, C}+ = {A, B, C, D, E, F, G, H, I, J}. So, it is a super key.
{A, C}+ = {A, B, C, D, E, F, G, H, I, J}. So, {A, B, C} is not a candidate key.

(d) [10 marks]

The table only has one candidate key, which is {A,C}.
We can observe that there are no non-prime attributes in R that partially depend on the candidate key {A, C}, satisfying the condition for 2NF. Therefore, the relation R is already in 2NF, i.e., R = {A, B, C, D, E, F, G, H, I, J}.