# CS411 Database Systems

*Fall 2009*

## HW#1

Due: 3:15pm CST, 09/22

Note: Print your name and NetID in the upper right corner of every page of your submission. Hand in your stapled homework to Donna Coleman in 2120 SC. In case Donna is not in office, slide your homework under the door.

To grade homeworks faster, the homework is partitioned into two parts (problems 1-3, 4-6). **Please, submit each part separately.** For each part, make sure to write down your name and NetID.

Expect to lose points if your handwritten answer is unclear or misread by the grader.

Part 1

## **Problem 1** E/R Diagram (15 points)

Suppose you are hired to develop a property management information system. Your first task is to develop its databases with the following information:

- A property management company has a unique name and a contact phone number, and may manage one or more apartments.
- An apartment has a unique address, the number of units, a leasing office, and one or more parking spaces. There is exactly one leasing office per one apartment.
- Each leasing office has a unique phone number and the number of staff.
- Parking space has a unique number and information on whether it is covered or not. An apartment has many parking spaces, and each parking space cannot be shared between different apartments even if they are close by, and each parking space number is unique for each apartment.
- Each utility company (electricity) is identified by a unique business registration number, has a name, and an address. Each electricity provider may supply electricity to multiple apartments, and an apartment has one supplier.

Please design and draw an E/R diagram that captures the above information. Be careful to indicate any key and participation constraints (multiplicity constraints). If you have assumptions, please specify them clearly (you may write them down as bullet points) so that graders understand your solution.

## <u>**Problem 2**</u> E/R Diagram, cont'd (15 points)

Following Problem 1, afterwards you recognize the need to refine the initial design, according to the following information.

- Each apartment has one or more units of different sizes.
- Each unit has a number unique within each apartment, and the unit can be leased by one or more tenants. Each tenant is not allowed to rent more than one unit in an apartment for availability reasons.
- Each unit has the number of rooms, the number of bathrooms, and the total area in square feet.
- Tenant's social security number, name and birthday must be recorded in the database.
- Leasing contracts are identified by their contract ID and the rental rate. Each contract consists of one unit and at least one tenant. We do not consider leasing parking spaces to simplify the problem.
- There are two kinds of leasing contracts: long term and monthly. They need to be separated because they will be treated differently. Long term lease will have specific start and end dates, and short term lease will only have a start date.

Please update your E/R diagram for Problem 1 to reflect the information given above. Also, be careful to indicate any participation constraint (multiplicity constraints), and roles. You may abbreviate portion of E/R diagram for Problem 1 that is not relevant to these enhancements, but please make sure you indicate clearly what has been abbreviated.

**<u>Problem 3</u>** Schema Design (10 points, 5 points each)

a) Convert the E/R diagram of Problem 1 to a relational database schema. Don't forget to indicate the keys (by underlining them) for each relation. You should reduce redundant relations if possible. (4 points)

b) Convert the Leasing contract entity hierarchy (Note you may use different names other than ones given here, as long as you make it clear for graders to understand) relationships in Problem 2 into relational schema, using the following three approaches: 1. ER approach, 2. Object-Oriented approach, 3. and Null approach. You should reduce redundant relations if possible. (6 points, 2 points for each approach)

Part 2

**Problem 4** Basic Concepts of Keys (20 points, 5 points each)

a) Given a relation R with $n$ attributes, explain how you can use the closure to test if a subset of attributes $A_1, A_2, ..., A_m$ is a candidate key for R (Note: $m \leq n$).

b) Suppose R is a relation with attributes $A_1, A_2, ..., A_n$. As a function of n, tell how many superkeys R has, if the only keys are A1 and A2.

c) Show that each of the following are *not* valid rules about FD's by giving example relations that satisfy the given FD's (following the "if") but not the FD that allegedly follows (after the "then"). Explain your answer and state any assumption you make.
1. If $A \rightarrow B$ then $B \rightarrow A$
2. If $AB \rightarrow C$ then $A \rightarrow C$ or $B \rightarrow C$

d) Consider a relation with schema R(A,B,C,D) with functional dependencies (FD's):

$BC \rightarrow A$, $AD \rightarrow B$, $CD \rightarrow B$, $AC \rightarrow D$.

Find all the candidate keys of R.

**<u>Problem 5</u>** Functional Dependency (20 points, 5 points each)

Consider a relation with schema R(A,B,C,D) and FDs $AC \rightarrow B$, $B \rightarrow A$, $BD \rightarrow C$ and $D \rightarrow A$.

a) Describe the concept of Functional Dependency and Dependency-preserving decomposition.

b) Find the closures for subsets A, BD and BC respectively.

c) List all nontrivial FD's that follow from the given FD's.

d) Find all the candidate keys for this relation (you don't need to list superkeys that are not keys). Explain your answer.

**<u>Problem 6</u>** Normalization and Schema Design (20 points, 5 points each)

Consider a relation R(A, B, C, D), with FDs $AB \rightarrow C$, $BC \rightarrow D$, $CD \rightarrow A$.

a) Is R in BCNF? Explain why or why not.

b) We are considering to decompose R into R1 (A, B, C) and R2 (A, C, D). Is this a lossless decomposition?

c) If you think that the relation R is not in BCNF, decompose the relation R into collections of relations that are in BCNF.

d) Is R in 3NF? If not, decompose the relation R into collections of relations that are in 3NF.