School of Engineering and Computer Science

SWEN304 **Database System Engineering**

Assignment 4

Due date: Friday 13 October at 5:00 pm
Venue: Cotton Building, Second Floor, SWEN 304 Hand-in Box

The objective of this assignment is to test your understanding of functional dependencies, normal forms, database normalization, EER modeling, and mappings from EER to RDM. The assignment is worth 5% of your final grade. It will be marked out of 100.

Submission instructions:

- Submit all your answers in a printed form.
- Upload all your answers on the proper branch of the VUW assessment system: https://apps.ecs.vuw.ac.nz/submit/SWEN304

Question 1. Functional Dependencies and Normal Forms [15 marks]

a) **[3 marks]** Consider a relation schema *N (R, F)* where $R = \{A, B, C\}$. Suppose we find the following two tuples in an instance of this relation schema.

A	*B*	*C*
1	*2*	*3*
4	*2*	*3*

Which of the following functional dependencies does definitely **not** hold over the relation schema *N*? Justify your answer.

1) $A \rightarrow C$

2) $B \rightarrow A$

3) $B \rightarrow C$

b) **[12 marks]** Consider a relation schema *N* (*R*, *F*) where $R = \{A, B, C, D\}$. For each of the following sets *F* of functional dependencies, determine which normal form (1NF, 2NF, 3NF, BCNF) the relation schema *N* is in. Justify your answer.

Hint: Note that in all four cases *AB* is the only key for *N*.

1) $F = \{AB \rightarrow C, C \rightarrow D\}$

2) $F = \{AB \rightarrow D, B \rightarrow C\}$

3) $F = \{AB \rightarrow C, AB \rightarrow D\}$

4) $F = \{ AB \rightarrow C, C \rightarrow B\}$

Question 2. Minimal Cover of a set of Functional Dependencies [10 marks]

Consider the set of functional dependencies $F = \{A \rightarrow B, B \rightarrow C, CD \rightarrow A, AC \rightarrow D\}$. Compute a minimal cover of F. Justify your answer.

Question 3. Normalization [35 marks]

a) **[10 marks]** Consider a relation schema $N(R, F)$ where $R = \{A, B, C, D\}$ and $F = \{A \rightarrow B, C \rightarrow D\}$. Perform the following tasks. Justify your answers.

1) Identify all keys for N.

2) Identify the highest normal form (1NF, 2NF, 3NF, BCNF) that N satisfies.

3) If N is not in 3NF, compute a lossless transformation into a set of 3NF relation schemas that preserve attributes and functional dependencies.

Hint: Verify explicitly that your result has the lossless property, satisfies 3NF, and that all attributes and functional dependencies are preserved.

b) **[10 marks]** Consider a relation schema $N(R, F)$ where $R = \{A, B, C, D\}$ and $F = \{B \rightarrow C, CD \rightarrow A, B \rightarrow D\}$. Perform the following tasks. Justify your answers.

1) Identify all keys for N.

2) Identify the highest normal form (1NF, 2NF, 3NF, BCNF) that N satisfies.

3) If N is not in 3NF, compute a lossless transformation into a set of 3NF relation schemas that preserve attributes and functional dependencies.

Hint: Verify explicitly that your result has the lossless property, satisfies 3NF, and that all attributes and functional dependencies are preserved.

c) **[15 marks]** Consider a relation schema $N(R, F)$, where $R = \{A, B, C, D\}$ and $F = \{A \rightarrow C, D \rightarrow B, BC \rightarrow A, BC \rightarrow D\}$. Perform the following tasks. Justify your answers.

1) Identify all keys for N.

2) Identify the highest normal form (1NF, 2NF, 3NF, BCNF) that N satisfies.

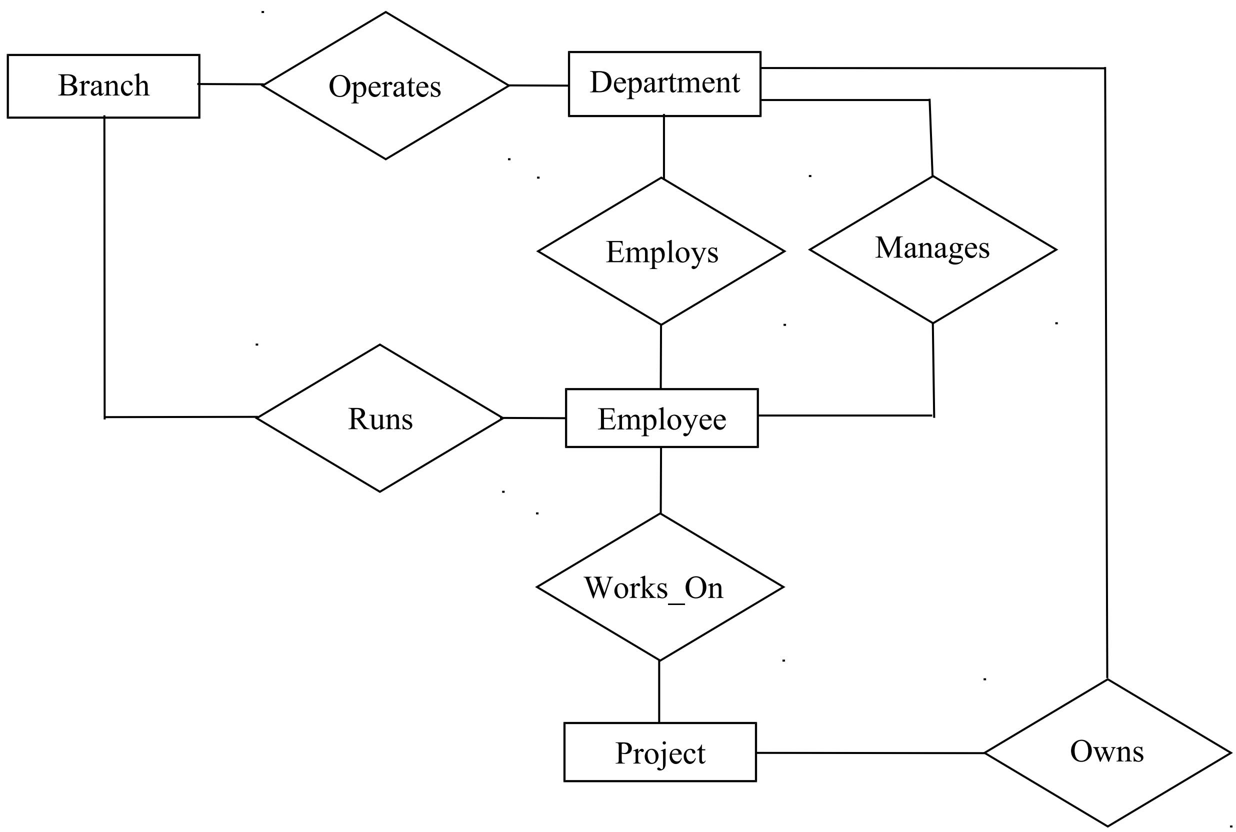
3) If N is not in BCNF, compute a lossless decomposition into a set of BCNF relation schemas that preserve attributes and functional dependencies.

Hint: Verify explicitly that your result has the lossless property, satisfies BCNF, and that all attributes and functional dependencies are preserved.

Question 4. Enhanced Entity Relationship Data Model [20 marks]

Consider the EER diagram shown below. Redraw the diagram to include the following structural constraints:

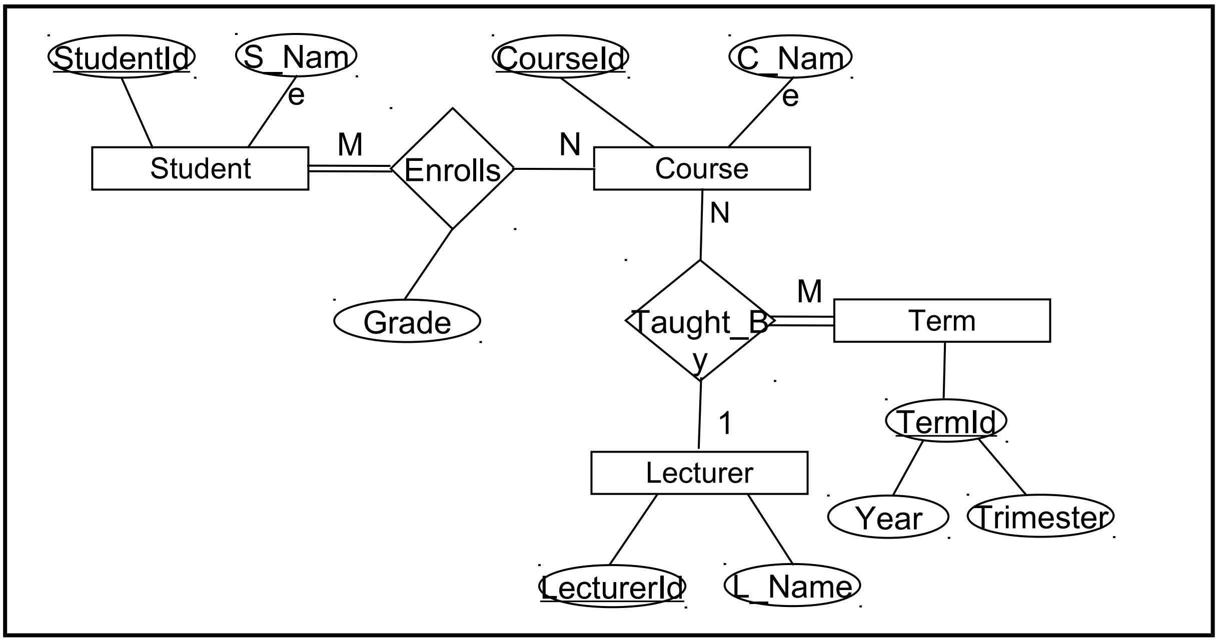
- A branch operates many departments, but each department is operated by only one branch. Each branch must have at least one department and each department must belong to a branch.
- A department employs many employees, but there may be a department with no employees.
- Most employees are employed by a department. They are known as "dept_emps". However, there are also employees who are not assigned to any department. They are known as "free_lance_emps".
- A department may own many projects, but there may be a department with no projects. Each project is existentially and identification dependent on only one department.
- Both dept_emps and free_lance_emps can work on many projects, but there are employees who do not work on any project. A project has at lest one employee working on it.
- One of dept_emps manages a department. Each department must have a manager.
- One of the employees runs a branch. Each branch must have someone running it.



Question 5. Mapping EER to Relational Data Model [20 marks]

The EER diagram below describes the following mini world:

- Students enroll into courses and get grades. If a student did not sit the exam of a course the corresponding grade value is undefined (null). A student may enroll into each course at most once. Each student must have at least one enrollment. There may be many students who enroll into the same course. There may be courses with no enrollments.
- Courses are taught by lecturers. A given lecturer may teach more than one course in a given term. There may be some courses that are not offered in a term. A given course in a given term may be taught by at most one lecturer. There may be some lecturers that do not teach any courses in a term. A given lecturer may teach a given course in several terms. In each term there is at least one course offered.



Note: In the ER diagram above, the "look across" approach to defining cardinality constraints has been used. In the "look across" approach, the cardinality constraints of a ternary relationship type are defined by taking a pair of instances of two entity types and determining the maximal number of instances of the third entity that can be associated with the pair. This number is recorded next to the third entity type. For example, a fixed (lecturer, term) pair may be associated by many (N) courses, since a lecturer may teach several courses in the same term. On the other hand, a (course, term) pair can be associated by at most one lecturer, since a course can be taught by at most one (1) lecturer in a given term. The participation constraints follow the "look here" approach.

Your tasks:

- Map the ER diagram above into a relational database schema.
- Define all constraints that follow from the EER diagram and the description of the mini world.

  Hint: Use the following notation: N(R, K) for relation schemes, N1[X] ⊆ N2[Y] for referential integrity constraints and other subset constraints, and Null(A) = N for an attribute A which is not allowed to contain a null value (assume null allowed is default). Recall, this is the notation we used in lectures.

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