Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

Faculty of Engineering, Mathematics and Science

School of Computer Science & Statistics

Integrated Computer Science **Hilary Term 2017**
Year 3 Annual Examinations

CS3041: Information Management II

10 January 2017 **Goldsmith Hall** **09.30-11.30**

Prof. Séamus Lawless and Prof. Vincent Wade

Instructions to Candidates:

Attempt **three** questions in total. **Question 1 is mandatory**. Answer **any two** questions from **Question 2, Question 3 and Question 4**.

All questions carry equal marks. Each question is scored out of a total of 25 marks. **Answer each question in a separate answer book.**

You may not start this examination until you are instructed to do so by the invigilator.

Materials Permitted for this examination:

None.

1. Niantic have recently released a location-based augmented reality mobile game called "Pokémon GO". Due to the popularity of the game, and the enormous volume of data being generated, the developers need to formally redesign the database to store all the information used in the application. The database has to store information related to every instance of a Pokémon and its GPS location. Each instance of a Pokémon has a Pokémon species, an evolution level and a combat power. The database must also store information about the people playing the game. Each player, once logged in, can 'capture' Pokémon by travelling to the same GPS location. Once captured, players can 'train' their Pokémon in a Gym. Gyms are located at identifiable real-world landmarks. Each player has a Pokédex, which is a list of the Pokémon that they have captured and own.

   a. Using the notation described in class, draw an Entity Relationship Diagram (ERD) for the above "real world" event. Map this Entity Relationship Diagram to a Relational Schema. Ensure you indicate the Primary Keys of your tables and any Foreign Keys. In addition, draw a Functional Dependency Diagram for this schema and ensure that the schema is in Boyce Codd normal form, explaining the steps of normalisation. State any assumptions that you make in your modelling of the database.

   [10 Marks]

   b. Write SQL Commands to do the following:

      i. Players in Pokémon GO can join one of three 'teams': Team Valor which is red; Team Mystic which is blue; or Team Instinct which is yellow. Using the appropriate SQL command, create a Team table that can store entries for each of these Teams. What adjustments would have to be made to link the Player table and the Team table? Demonstrate using SQL.

      [4 Marks]

(Question 1 continues on next page)...

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(Question 1 continued from previous page)...

ii. Write a retrieval command which checks how many players have captured a Pokémon called "Charizard".

[3 Marks]

iii. Players earn experience points as they play the game. For every 1000 experience points earned, the player moves up a 'level'. It is only at level five that players can 'battle' Pokémon against each other. Suppose you have a table BATTLE which records the instances of Pokémon, selected by players, who are about to do battle with each other. Using the appropriate SQL command, demonstrate how the database could ensure that both players in a 'battle' are at the appropriate level.

[4 Marks]

iv. A disagreement over naming rights has resulted in a specific Pokémon called "Bulbasaur" having to be removed from Pokémon GO. Remove this Pokémon from the database using the appropriate SQL command. How would referential integrity impact this procedure and what steps should be taken to avoid such issues?

[4 Marks]

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2.

a. What are the four essential properties of a transaction? Explain each of these properties.

[3 Marks]

b. Concurrently executing transactions can cause a number of problems if they are not correctly scheduled. Discuss, with examples, the concurrency control problems of "Lost Update", "Temporary Update (Dirty Read)" and "Incorrect Summary".

[5 Marks]

c. When are operations in a schedule deemed to be in conflict? Illustrate with an example.

[3 Marks]

d. Serializable schedules are those which are said to be equivalent to a serial schedule. How is equivalence measured?

[3 Marks]

e. Explain how concurrency control algorithms, which are based upon locking techniques, ensure that concurrently executing transactions do not interfere with each other's execution. Make reference to both binary and read-write locking. Two-phase locking is an additional locking protocol. Discuss two-phase locking and the benefits it offers.

[6 Marks]

(Question 2 continues on next page)...

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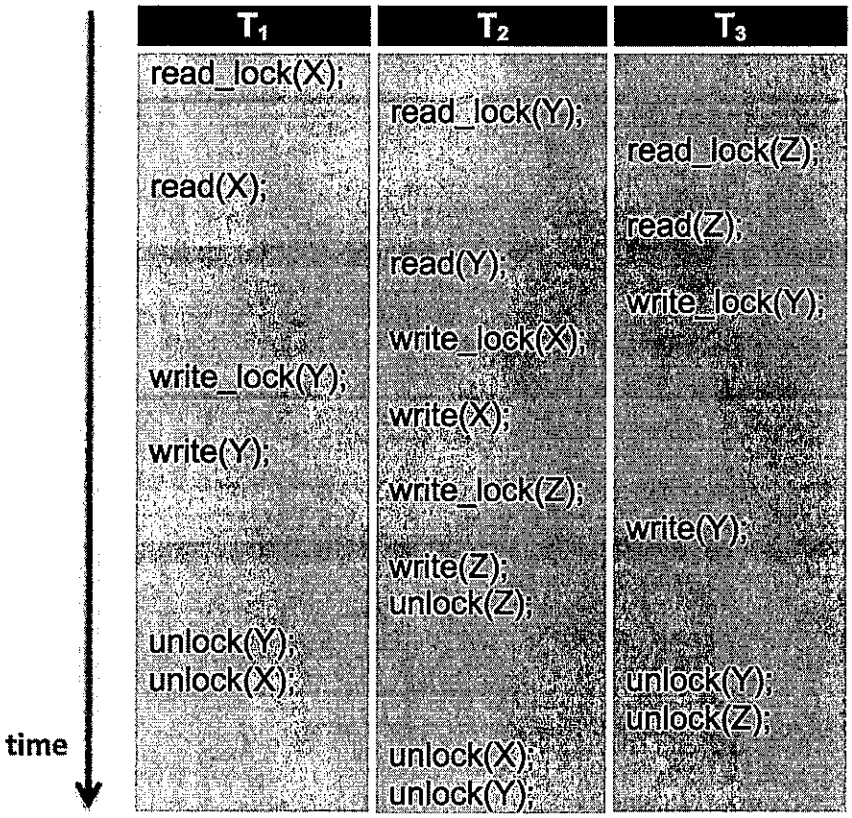
(Question 2 continued from previous page)...

f. Outline the operation of the "Wound-Wait" algorithm. Indicate how "Wound-Wait" would execute the following schedule. You may assume that T_1 is older than T_2, and T_2 is older than T_3. State any assumptions that you make in determining transaction operation ordering.



[5 Marks]

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3.

a. Distinguish between Security and Integrity in a relational database.

[2 Marks]

b. What is a database constraint? Distinguish between explicit constraints and semantic constraints. Define three basic types of integrity constraint that all relational databases must support.

[5 Marks]

c. What operations on a database can violate referential integrity? What clauses and constraints can be used to avoid violating referential integrity? Use a CREATE TABLE statement for one of the tables in Question 1 of this paper to help illustrate your answer.

[5 Marks]

d. Access Control is often used to secure a relational database. Discuss the various means by which a DBMS can manage access control. Make specific reference to privileges, propagation and the risks involved. Compare and contrast Discretionary Access Control and Mandatory Access Control?

[7 Marks]

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(Question 3 continued from previous page)...

e.

i. What SQL command(s) would be used to create a database object that only displays a subset of attributes from a table? Use a table from Question 1 of this paper to demonstrate.

[2 Marks]

ii. What SQL command(s) would be used to allow a user called "Elliot Alderson" to read and update the information contained within this subset of attributes? How would you modify this command(s) to allow Elliot to pass on these permissions to other users?

[2 Marks]

iii. What SQL command(s) would be used to remove the permission to update from "Elliot Alderson"?

[2 Marks]

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4.

a. Describe the common characteristics that distinguish "NoSQL" databases from Relational databases.

[5 Marks]

b. Describe key-value databases, their pros and cons, and two possible use cases.

[5 Marks]

c. Describe Graph databases, how they function and their differences with respect to Relational databases.

[5 Marks]

d. Explain the CAP Theorem and its implications for NoSQL databases.

[7 Marks]

e. Describe briefly the two main techniques used for data distribution in NoSQL databases.

[3 Marks]

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