



**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**  
**BA (Mod) Computer Science and Business**  
**Year 3 Annual Examinations**

**Hilary Term 2018**

**Information Management II**

**9 January 2018**

**Goldsmith Hall**

**09.30-11.30**

**Prof. Séamus Lawless, Prof. Vincent Wade, Dr. Annalina Caputo**

**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. The up-and-coming internet start-up company “Pied Piper” have recently decided to develop a Video Chat application. The initial stages of this development require the design of a database to store all the information related to the users of the application. *PiperChat* has to store information related to:

- individuals and their profile details
- connections between Pied Piper users in the form of contact lists
- chat sessions between two individuals and between groups of people
- text, images, videos and audio clips which can be sent as part of a chat session

Each individual must be able to see the other Pied Piper users that they are connected to (are in their contact list), the previous chat sessions that they have had, and the media files that they have sent and received.

- a. Using the notation described in class, draw an Entity Relationship Diagram (ERD) for the above “real world” application. 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, clearly explaining all the steps of normalisation. State any assumptions that you make in your modelling of the database.

[10 Marks]

- b. A new feature is being added to the PiperChat application. A “type” can be specified for each contact when it is added e.g. “Friend”, “Family”, “Work Colleague”. When creating a group conversation, you can also give the conversation a similar “type”. Using the appropriate SQL command, update your contact table to include a contact type. When adding a new contact to a conversation, how could the database ensure that the contact is of an appropriate type, i.e. only Work Colleagues can be added to a Work conversation?

[4 Marks]

(Question 1 continues on next page)...

(Question 1 continues from previous page)...

- c. Using the appropriate SQL command, create the database table from your Entity Relationship Diagram that stores an entry for each user of PiperChat, including their personal details.

[3 Marks]

- d. Write SQL Commands to do the following:

- i) One of the users in the database has decided to change their name; update the name of the user to reflect this change.

[3 Marks]

- ii) Retrieve all of the conversations that “Jared Dunn” was a participant in during 2017.

[2 Marks]

- iii) Write a retrieval command which returns all video chat sessions which have more than 10 participants.

[3 Marks]

2.

- a) What are the four desirable properties of a transaction? Explain each of these properties.

[3 Marks]

- b) Define the properties of a “serial schedule”. What can be assumed about a serial schedule and what are the potential issues? Discuss “serializability” as a way of addressing these issues. How is serializability measured?

[5 Marks]

- c) 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.

[5 Marks]

(Question 2 continues on next page)...

- | T <sub>1</sub>                        | T <sub>2</sub>  | T <sub>3</sub>                              |
|---------------------------------------|---|---|
| read_lock(Y);<br>read(Y);             | read_lock(X);   | read_lock(Z);<br>read(Z);<br>write_lock(Y); |
|                                       | read(X);<br>write_lock(Z);<br>write(Z);<br>unlock(Z); |   |
| write_lock(X);                        |   | write(Y);<br>unlock(Y);<br>unlock(Z);       |
| write(X);<br>unlock(Y);<br>unlock(X); | unlock(X);  |   |

e) Compare and contrast pure timestamp-based concurrency control with lock-based techniques. What problem(s) does timestamp ordering prevent?

f) What timestamp values must be stored for each data item in a database? What process occurs when a transaction issues a Read, and when a transaction issues a Write?

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3.

- a. What are privileges, and why are they used in database systems? Describe the two levels of privilege used and identify example commands from each level. Describe, with the aid of the appropriate SQL commands, how privileges can be assigned and removed.

[5 Marks]

- b. Privilege propagation is an important aspect of Discretionary Access Control. Describe propagation, making specific reference to the dangers involved.

[3 Marks]

- c. Compare and Contrast Discretionary Access Control and Mandatory Access Control.

[2 Marks]

- d. 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]

- e. 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]

- f. Why are views important and what can they be used to restrict? Using the appropriate SQL command, create a new view, which is used to display information from at least two of your tables from Question 1.

[5 Marks]

4.

- a. Given the two tables from a relational database shown below, provide an equivalent representation (JSON) for a document database. Briefly explain what would be the main difference between the two representations in terms of data normalisation.

[5 marks]

Author Table

AuthorID	Name	Surname	PostID
32456	John	Murphy	2164

Post Table

PostID	Text	Date
2164	There is an interesting blog post about ML ...	13/11/2017
2546	If you're on the mailing list, the latest edition of NLP News just	11/11/2017

- b. Provide a practical example where the use of graph databases is more beneficial than relational databases. Explain why graph databases would be more suitable in this situation.

[5 marks]

- c. What does BASE stand for and what is its relationship to ACID?

[4 marks]

- d. What does the acronym CAP stand for? Describe the CAP theorem.

[6 marks]

- e. List at least five characteristics that distinguish NoSQL databases from relational databases.

[5 marks]