DI- FCT/UNL **10 de julho de 2023**

Database Systems

2nd test 2023/24

Duration: 2 hours (limited consultation)

Group 1 (each question is worth 2,5 values out of 20)

Consider part of a database for a national library (the attributes forming the primary key are underlined):

Authors({<u>authorID</u>,name,birthdate,country,...}) AuthorsBooks({<u>authorID</u>,<u>bookID</u>,authorNR})

Books({<u>bookID</u>,title,year,summary}) BooksGenres(<u>bookID</u>,<u>genreID</u>)

Copies(<u>bookID</u>,<u>copyNR</u>,status,lent) Genres(<u>genreID</u>,description)

The authors are identified by an integer primary key, and have a name, birth date and birth country. The books are also identified by an integer primary key, and have a title, edition year and summary of content. Each book may have several authors, stored in AuthorBooks table, where the authorNR column is an integer attribute capturing the author order (1, for the first author, etc…) . Each book can have several copies, distinguished by the copyNR attribute (numbered sequentially in each book), and the copy status is a string describing if the book is damaged, and the lent attribute is a boolean indicating if the book has been borrowed by some reader. The Genres table simply has a textual description of the existing Genres (e.g. History, Science Fiction, etc…), and the BookGenres table associates each Book with the corresponding Genres. For each of these tables there is a secondary B+ tree (non-clustering) index on the primary key attribute(s), created with the column order indicated in the tables. Additionally, there is a primary (clustered) index for Books(title).

The adopted DBMS uses blocks of 8KiB (8192 bytes). The records of all tables have a variable size, and, on average, a record of the Authors table occupies 1KiB, a book record occupies 2KiB, a record of Copies, Genres, and AuthorsBooks occupy 128 bytes, and BookGenres records' occupy 32 bytes. At any given time, the Authors table has 100,000 tuples, the Books table 1,000,000 tuples, the Copies table has 5,000,000 tuples, the Genres table has 1,000 tuples. The AuthorsBooks has 4,000,000 tuples, and the BooksGenres has 2,000,000 tuples. A B+ tree node can contain about 100 search keys, and it is known that a seek time is 10ms and the transfer time of a block t_T is 1ms, while the memory only holds 100 blocks.

Note: In this group, whenever examples are requested, these must be exclusively about this database, Additionally, all the answers must contain a brief justification.

1 a) Determine the estimated number of tuples returned for the following query, assuming uniform distribution of BookGenres

```
SELECT Books.*
FROM Books NATURAL INNER JOIN BooksGenres NATURAL INNER JOIN Genres
WHERE description = 'History' or description='Economy'
```

1 b) Consider the following schedule of two SQL transactions. Place the lock-S, lock-X, and unlock instructions in this schedule to comply with the rigorous two phase locking protocol. Explain what would happen in terms of executing these transactions.

	Transaction T1:	**Transaction T2:**
1	SELECT COUNT(*) INTO n1 FROM Authors WHERE name IN ('Fernando Pessoa', 'Luís Vaz de Camões','José Saramago')	
2	UPDATE Authors SET ... WHERE name='Fernando Pessoa'	
3		UPDATE Authors SET ... WHERE name ='José Saramago'
4	SELECT COUNT(*) INTO n3 FROM Authors;	
5	COMMIT	
6		UPDATE Authors SET ... WHERE name ='Eça de Queirós'
7		COMMIT

1 c) Consider the following recovery log record of a DBMS with memory buffering of disk blocks in which disk writes are only performed when checkpoints are performed (you can assume that there is no log buffering). The memory is initially empty. Complete the log knowing that the system has recovered from the recorded failure, indicating for the items referred to in the log the status of the disk and memory at each moment since the start of operation, as well as the values of X and Y at the checkpoints.

	Log
1	<T1, start>
2	<T2,start>
3	<T2, Copies(1,1).lent,False,True>
4	<T1, Copies(1,2).lent,False,True>
5	<T1, commit>
6	<T3, start>
7	<checkpoint X>
8	<T3, Copies(1,3).lent,False,True>
9	<T3, Copies(1,3).lent,False>
10	<T2, Copies(1,4).lent,True,False>
11	<checkpoint Y>
12	<T2, Copies(1,2).lent,True,False>
13	CRASH

1 d) Transactions in the schedule below are executed in SNAPSHOT ISOLATION mode. Assuming the database tables are initially empty, display the contents of table N at the end of the run knowing that it only has one column and no integrity constraints are in effect. Verify that the indicated schedule is serializable.

Passo	Transação T1:	Transação T2:	Transação T3:
1		begin transaction INSERT INTO Authors VALUES(1,'Fernando Pessoa',…)	
2		INSERT INTO Authors VALUES(2,'Luís Vaz de Camões',…)	
3		INSERT INTO N SELECT COUNT(*) FROM Authors;	
4		COMMIT	
5	begin transaction INSERT INTO Authors VALUES(3,'Eça de Queirós',…)		
6			begin transaction INSERT INTO Authors VALUES(4,'José Saramago',…)
7	INSERT INTO N SELECT COUNT(*) FROM Authors;		
8			INSERT INTO N SELECT COUNT(*) FROM Authors;
9			COMMIT
10	INSERT INTO N SELECT COUNT(*) FROM Authors;		
11	COMMIT		

1 e) Consider the following distributed transaction that takes place at two different locations correcting the title from book with BookID 2 from "Os Lusiadas" to "Os Lusíadas", and from BookID 1 from "The Message" to "A Mensagem". Indicate the concurrency control log records (in order) of the coordinator and of each of the sites knowing that the transaction is coordinated by machine 2, that it had a failure detected by the coordinator at step 4 after preparing the transaction, and that it is used 2 phase commit for concurrency control.

#	Local 1	Local 2
1	begin transaction	
2	UPDATE Books SET title = 'Os Lusíadas' WHERE bookID = 2;	
3		UPDATE Books SET title = 'A Mensagem' WHERE BookID = 1;
4		COMMIT...

Group2 (each question is worth 2,5 values out of 20)

Note: the answer to each question cannot exceed 1 page

2 a) The cardinality of the natural join r⋈s between tables r and s of schema R and S, respectively, can be estimated by the expression below for the case where $R \cap S = \{A\}$ is not a key of either R or S. Explain the formula intuition, knowing that n_r and n_s are respectively the number of tuples of r and s.

$$n_{r \bowtie s} = \min\left(\frac{n_r * n_s}{V(A,r)}, \frac{n_r * n_s}{V(A,s)}\right)$$

2 b) Explain the advantages and disadvantages of the SNAPSHOT ISOLATION mode, illustrating the problem of skewed writes.

2 c) Explain the difference between fuzzy checkpointing and normal checkpointing, indicating the advantages of the first over the second.

THE END