Course: CS3402 Database Systems
Term: 2020-21 Semester B
Assignment #3 (100 marks)
Submission deadline: May 01, 2021

Name: _____

Student ID: _____

Question 1. Suppose that we construct a B^+ tree with 3 levels, in which the order of internal nodes is 20 and the order of leaf nodes is 20, what is the maximum number of data record pointers for this B^+ tree? Please show the number of key entries (or data record entries) and the number of pointers at the root, level 1, level 2 and leaf level. [20 marks]

Root:	1 node	19 key entries	20 pointers	[5 marks]
Level 1:	20 nodes	380 key entries (20*19)	400 pointers	[5 marks]
Level 2:	400 nodes	7,600 key entries (400*19)	8,000 pointers	[5 marks]
Leaf level:	8,000 pointers	152,000 data record entries (8,000*19) Alternative solution: 160,000 data record entries (8,000*20)		[5 marks]

The maximum number of data record pointers is 152,000 or 160,000.

Question 2. Suppose that the size of a search key field is V=9 bytes, the size of a record pointer is Pr=7 bytes, the size of a block pointer/tree pointer is P=6 bytes, the order of internal nodes (p) is 20, and the number of data record points for a leaf node 20 for a B^+ tree. What should be the minimum required block size B for this B^+ tree. [20 marks]

For internal nodes:
$(p * P) + ((p - 1) * V) \leq B$
$(20 * 6) + ((20 - 1) * 9) \leq B$
$291 \leq B$ [8 marks]

For leaf nodes:
$(p_{leaf} * (Pr + V)) + P \leq B$
$(20 * (7+ 9)) + 6 \leq B$
$326 \leq B$ [8 marks]

The minimum required block size B is 326. [4 marks]

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Question 3. The following table shows the schedule for transactions T_1, T_2 and T_3 with T_1 having an "older" timestamp than T_2 and T_2 is older than T_3. Use unlock(A) and unlock(B) to release a read_lock or write_lock on A and B, respectively.

T_1	**T_2**	**T_3**
read(A);		
	read(B);	
write(B);		
		write(A);
	write(A);	
commit;		
	commit;	
		write(B);
		commit;

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(a) If B2PL (Basic Two-Phase Locking) is used for concurrency control, dose B2PL cause any deadlock? If yes, what is the cycle in the wait-for graph. If no, what is the final schedule for these three transactions? [20 marks]

[This table is just for reference; it is not part of the answer.]

T_1	**T_2**	**T_3**
read_lock(A); read(A);		
	read_lock(B); read(B);	
write(B); (blocked)		
		write(A); (blocked)
	write(A); (blocked)	
commit;		
	commit;	
		write(B);
		commit;

Yes, B2PL causes a deadlock. [5 marks]
The cycle in the wait-for-graph is $T_1 \rightarrow T_2 \rightarrow T_1$ (or $T_2 \rightarrow T_1 \rightarrow T_2$). [15 marks]

(b) If C2PL (Conservative Two-Phase Locking) is used for concurrency control, does C2PL cause any deadlock? If yes, what is the cycle in the wait-for graph. If no, what is the final schedule for these three transactions? [20 marks]

[This table is just for reference; it is not part of the answer.]

T_1	**T_2**	**T_3**
read_lock(A) ; write_lock(B);		
read(A);		
write(B);		
commit;		
unlock(A); unlock(B);		
	read_lock(B); write_lock(A);	
	read(B);	
	write(A);	
	commit;	
	unlock(B);unlock(A);	
		write_lock(A); write_lock(B);
		write(A);
		write(B);
		commit;
		unlock(A); unlock(B);

No, C2PL does not cause any deadlock. [5 marks]
The final schedule is T_1, T_2 and T_3 (or T1 => T2 => T3). [15 marks]

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(c) If the S2PL (Strict Two-Phase Locking) is used for concurrency control and the wait-die method is used to prevent deadlock, which transaction(s) will be restarted? For a transaction that must be restarted, please state the reasons (including which transaction and database item it restarts for). [20 marks]

[This table is just for reference; it is not part of the answer.]

T_1	**T_2**	**T_3**
read_lock(A); read(A);		
	read_lock(B); read(B);	
write(B); (blocked)		
		write(A); (T_3 restarts because T_3 is younger than T_1.)
	write(A); (T_2 restarts because T_2 is younger than T_1.)	
write_lock(B); write(B);		
commit;		
unlock(A); unlock(B);		

T_3 will be restarted. T_3 waits for database item A which is being locked by T_1. [10 marks]
T_2 will be restarted. T_2 waits for database item A which is being locked by T_1. [10 marks]