CS3223 Tutorial 9: Crash Recovery & Multigranular Locking

Wk 12, Sem 2, 2022/23

1. (Exercise 17.11, R&G) Consider a database organized in terms of the following hierarchy of objects: The database itself is an object (D), and it contains two files (F1 and F2), each of which contains 1000 pages (P1 $\cdots$ P1000 and P1001 $\cdots$ P2000, respectively). Each page contains 100 records, and records are identified as p:i, where p is the page identifier and i is the slot of the record on that page. Multiple-granularity locking is used, with S, X, IS, and IX locks, and database-level, file-level, page-level and record-level locking. For each of the following operations, indicate the sequence of lock requests that must be generated by a transaction that wants to carry out (just) these operations:
   (a) Read record P1200:5.
   (b) Read records P1200: 98 through P1205:2.
   (c) Read all (records on all) pages in file F1.
   (d) Read pages P500 through P520.
   (e) Read pages P10 through P980.
   (f) Read all pages in F1 and (based on the values read) modify 10 pages.
   (g) Delete record P1200:98. (This is a blind write.)
   (h) Delete the first record from each page. (Again, these are blind writes.)
   (i) Delete all records.

2. (Exercise 18.3, R&G) Suppose the database system has just crashed with the log contents shown below. Assume that both the Dirty Page Table as well as the Transaction Table associated with the end_checkpoint_record log record are empty.

LOG

LSN	type	XactID	pageID	prevLSN	undoNextLSN
00	begin_checkpoint				
10	end_checkpoint				
20	update	T_1	P5		
30	update	T_2	P3		
40	commit	T_2		30	
50	end	T_2		40	
60	update	T_3	P3		
70	abort	T_1		20	

   (a) Show the contents of the *Dirty Page Table* and *Transaction Table* at the end of the Analysis phase.
   (b) What is the value of RedoLSN?
   (c) Show all the log records that are generated by the Undo phase. For each log record, you only need to indicate the relevant information based on its type. Assume that the sequence of new log records have LSNs 80, 90, 100, etc.

3. (Exercise 18.5, R&G) Suppose the database system has just crashed with the log contents shown below. Assume that both the Dirty Page Table as well as the Transaction Table associated with the end_checkpoint_record log record are empty.

LOG

LSN	type	XactID	pageID	prevLSN	undoNextLSN
00	begin_checkpoint				
10	end_checkpoint				
20	update	T_1	P1		
30	update	T_2	P2		
40	update	T_3	P3		
50	commit	T_2		30	
60	update	T_3	P2	40	
70	end	T_2		50	
80	update	T_1	P5	20	
90	abort	T_3		60	

(a) Show the contents of the *Dirty Page Table* and *Transaction Table* at the end of the Analysis phase.

(b) What's the value of RedoLSN?

(c) Show all the log records that are generated by the Undo phase. For each log record, you only need to indicate the relevant information based on its type. Assume that the sequence of new log records have LSNs 100, 110, 120, etc.

4. This question examines system recovery using the ARIES algorithm. A system failure has just occurred and the contents of the log file are shown in Figure 1(a), where for each of the log records, only the relevant information (based on the type of the log record) are indicated. The *Dirty Page Table* and *Transaction Table* associated with the *end_checkpoint* log record are shown in Figures 1(b) and (c), respectively.

LOG

LSN	type	XactID	pageID	prevLSN	undoNextLSN
00	update	T_3	P1		
10	update	T_3	P2	00	
20	update	T_1	P3		
30	update	T_2	P7		
40	update	T_2	P5	30	
50	update	T_1	P2	20	
60	update	T_1	P3	50	
70	begin_checkpoint				
80	end_checkpoint				
90	update	T_3	P5	10	
100	update	T_3	P4	90	
110	update	T_4	P5		
120	abort	T_3		100	
130	CLR	T_3	P4	120	90
140	update	T_1	P6	60	

(a)

DIRTY PAGE TABLE

pageID	recLSN
P3	20
P2	50

(b)

TRANSACTION TABLE

XactID	lastLSN	status
T_1	60	U
T_2	40	U
T_3	10	U

(c)

Figure 1: Log File

(a) Show the contents of the *Dirty Page Table* and *Transaction Table* at the end of the Analysis phase.

(b) What is the value of RedoLSN?

(c) In the Redo phase, to determine whether or not a redoable log record needs to be redone might require accessing the affected page. List down the LSNs of all the redoable log records that do not require a page access for this checking.

(d) Show all the log records that are generated by the Undo phase. For each log record, you only need to indicate the relevant information based on its type. Assume that the sequence of new log records have LSNs 150, 160, 170, etc.