

1 Recovery Q1

Consider the execution of the ARIES recovery algorithm given the following log (assume a checkpoint is completed before LSN 0 and the Dirty Page Table and Transaction Table for that checkpoint are empty):

LSN	Log Record
10	update: T1 writes P1
20	update: T2 writes P3
30	T1 commit
40	update: T3 writes P4
50	update: T2 writes P1
60	T1 end
70	update: T3 writes P2
80	T2 abort

- (a) During Analysis, what log records are read? What are the contents of the transaction table and the dirty page table at the end of the analysis stage?

Solution: All records (since the last checkpoint) are read. We read through the log forwards and add entries to the transaction table and the dirty page table. Note that lastLSN is the last LSN written by a transaction, while recLSN is the LSN which first caused a page to be dirty.

Transaction Table			Dirty Page Table	
Transaction	lastLSN	Status	PageID	recLSN
T3	90	Aborting	P1	10
T2	80	Aborting	P2	70
			P3	20
			P4	40

- (b) During Redo, what log records are read? What data pages are read? What operations are redone (assuming no updates made it out to disk before the crash)?

Solution: Redo starts at LSN 10 (smallest recLSN in the dirty page table). All pages in the dirty page table are read from disk (i.e. P1, P2, P3, P4). Assuming no updates made it to disk, the pageLSN of each page on disk is always less than the current LSN, so all updates and CLR's are redone. The LSN's of these operations are: 10, 20, 40, 50, 70.

(c) During Undo, what log records are read? What operations are undone? Show any new log records that are written for CLR's. Start at LSN 100. Be sure to show the undoNextLSN.

Solution: The lastLSN in the transaction table is 90. Starting from here, we will read: 90, 80, 70, 50, 40, 20. Of these, the update operations are: 70, 50, 40, 20. Therefore, the new log records are:

LSN	Record	prevLSN	undoNextLSN
100	CLR: undo T3 LSN 70	90	40
110	CLR: undo T2 LSN 50	80	20
120	CLR: undo T3 LSN 40	100	null
130	T3 end	120	-
140	CLR: undo T2 LSN 20	110	null
150	T2 end	140	-

2 Recovery Q2

Your database server has just crashed due to a power outage. You boot it up, find the following log and checkpoint information on disk, and begin the recovery process. Assume we use a STEAL/NO FORCE recovery policy.

LSN	Record	prevLSN
30	update: T3 writes P5	null
40	update: T4 writes P1	null
50	update: T4 writes P5	40
60	update: T2 writes P5	null
70	update: T1 writes P2	null
80	begin_checkpoint	-
90	update: T1 writes P3	70
100	end_checkpoint	-
110	update: T2 writes P3	60
120	T2 commit	110
130	update: T4 writes P1	50
140	T2 end	120
150	T4 abort	130
160	update: T5 writes P2	null
180	CLR: undo T4 LSN 130	150

Transaction Table			Dirty Page Table	
Transaction	lastLSN	Status	PageID	recLSN
T1	70	Running	P5	50
T2	60	Running	P1	40
T3	30	Running		
T4	50	Running		

On-Disk Page LSN Table	
PageID	pageLSN
P1	0
P2	70
P3	110
P4	0
P5	30

- (a) The log record at LSN 60 says that transaction 2 updated page 5. Was this update to page 5 successfully written to disk? The log record at LSN 70 says that transaction 1 updated page 2. Was this update to page 2 successfully written to disk? Assume for this question we do not have access to the On-Disk Page LSN Table.

Solution: The update at LSN 60 may have been written to disk. The log entry was flushed before the write itself. It was not yet flushed at the time of the checkpoint, but may have been flushed later. The update at LSN 70 was flushed to disk. We know this because it's not in the dirty page table at the time of the checkpoint.

- (b) At the end of the analysis phase, what transactions will be in the transaction table, and what pages will be in the dirty page table?

Solution: Note that P1 and P5 were already in the dirty page table during the checkpoint, and their recLSN's do not change during analysis

Transaction Table			Dirty Page Table	
Transaction	lastLSN	Status	PageID	recLSN
T1	190	Aborting	P1	40
T3	200	Aborting	P2	160
T4	180	Aborting	P3	90
T5	210	Aborting	P5	50

- (c) At which LSN in the log should the redo phase begin? Which log records will be redone (list their LSNs)? All other log records will be skipped.

Solution: Redo should begin at LSN 40, the smallest of the recLSNs in the dirty page table. The following log records should be redone: 40, 50, 60, 130, 160, 180. 30 is skipped because it precedes LSN 40. 70 is skipped because $P2.\text{recLSN} = 160 > 70$. 90 and 110 are skipped because the LSNs are \leq relevant pageLSN on disk. Entries that are not updates are skipped. The CLR record is not skipped, nor is the LSN that it undoes.

(d) Write down all of the log records written during the undo phase.

Solution: Undo should begin at LSN 210 because of additional abort records written during the Analysis phase. The update operations that are undone are: 160, 90, 70, 50, 40, 30. After all operations of an aborting transaction are undone, we also write an end record. Therefore, log records written during the Undo phase are:

LSN	Log Record	<u>prevLSN</u>	undoNextLSN
220	CLR: undo T5 LSN 160	210	null
230	T5 end	220	-
240	CLR: undo T1 LSN 90	190	70
250	CLR: undo T1 LSN 70	240	null
260	T1 end	250	-
270	CLR: undo T4 LSN 50	180	40
280	CLR: undo T4 LSN 40	270	null
290	T4 end	280	-
300	CLR: undo T3 LSN 30	200	null
310	T3 end	300	-