Fall 2004 Exercise Solutions
Week 15 – Ending 12/10/04

Solution
1.
   a) No. Uncommitted data is never written to disk.
   b) Yes. Some committed data might have not been written to disk yet.
   c) Yes. Some uncommitted might have been written to disk.
   d) Yes. We need to repeat history, including looser transactions, before starting the UNDO phase.
   e) Begin_checkpoint of the most recent checkpoint
   f) Smallest recLSN in dirty page table at the end of Analysis
   g) Oldest log record of transactions active at crash

2.
   a) Analysis determines that the last begin_checkpoint was at LSN 00 and starts at the corresponding end_checkpoint (LSN 10). Transaction Table records are denoted as (transID, lastLSN, status) and Dirty Page Table records are denoted as (pageID, recLSN) sets. Analysis phase runs till LSN 70 and does the following:

   LSN 20  Adds (T1, 20, U) to TT and (P5, 20) to DPT.
   LSN 30  Adds (T2, 30, U) to TT and (P3,30) to DPT.
   LSN 40  Changes (T2, 30, U) to (T2, 40, C).
   LSN 50  Deletes entry for T2 from Transaction Table.
   LSN 60  Adds (T3, 60, U) to TT. Does not change P3 entry in DPT.
   LSN 70  Adds (P2, 70) to DPT and Changes (T1, 20, U) to (T1, 70, U).
   LSN 80  Changes (T1, 70, U) to (T1, 80, A).

   The final Transaction Table has two entries: (T1, 80, A), and (T3, 60, U).
   The final Dirty Page Table has three entries (P5,20), (P3,30), and (P2, 70).

   b) REDO
   LSN 20  P5 is retrieved and its pageLSN is checked. If the page had been written to disk before the crash (i.e. if pageLSN >= 20), nothing is redone otherwise the changes are redone.
   LSN 30  P3 is retrieved and its pageLSN is checked. If the page had been written to disk before the crash (i.e. if pageLSN >= 30), nothing is redone otherwise the changes are redone.
   LSN 40  No action
   LSN 50  No action
   LSN 60  P3 is retrieved and its pageLSN is checked. If the page had been written to disk before the crash (i.e. if pageLSN >= 60), nothing is redone otherwise the changes are redone.
   LSN 70  P2 is retrieved and its pageLSN is checked. If the page had been written to disk before the crash (i.e. if pageLSN >= 70), nothing is redone otherwise the changes are redone.
   LSN 80  No action
c) UNDO phase starts at LSN 80 (highest lastLSN in TT). The ToUndo consists of LSNs 80 and 60 for loser transactions T1 and T3 respectively.

- **LSN 80**: Removes 80 from the ToUndo. Adds LSN 70 to the ToUndo.
  - ToUndo = (70, 60).

- **LSN 70**: Removes 70 from the ToUndo. Undoes the change on P2 and adds a CLR indicating this Undo (LSN 90, undoNextLSN = 20).
  - ToUndo = (60, 20).

- **LSN 60**: Undoes the change on P3 and adds a CLR indicating this Undo (LSN 100, undoNextLSN = null).
  - ToUndo = (20).

- **LSN 20**: Undoes the change on P5 and adds a CLR indicating this Undo (LSN 110, undoNextLSN = null).

3)

a) LSN 00 is stored in the master log record as it is the LSN of the begin checkpoint record.

b) During analysis the following happens:

- **LSN 20**: Add (T1, 20) to TT and (P1, 20) to DPT
- **LSN 30**: Add (T2, 30) to TT and (P2, 30) to DPT
- **LSN 40**: Add (T3, 40) to TT and (P3, 40) to DPT
- **LSN 50**: Change status of T2 to C
- **LSN 60**: Change (T3, 40) to (T3, 60)
- **LSN 70**: Remove T2 from TT
- **LSN 80**: Change (T1, 20) to (T1, 70) and add (P5, 70) to DPT
- **LSN 90**: No action

At the end of analysis, we have:

- Transaction table: (T1, 80), and (T3, 60).
- Dirty Page Table: (P1, 20), (P2, 30), (P3, 40), and (P5, 80).

3) c) Redo starts from LSN20 (minimum recLSN in DPT).

- **LSN 20**: Check whether P1 has pageLSN more than 10 or not. Since it is a committed transaction, we probably need not redo this update.
- **LSN 30**: Redo the change in P2
- **LSN 40**: Redo the change in P3
- **LSN 50**: No action
- **LSN 60**: Redo the changes on P2
- **LSN 70**: No action
- **LSN 80**: Redo the changes on P5
- **LSN 90**: No action
d) The ToUndo consists of (80, 60) for loser transactions T1 and T3 respectively. Undo starts with the highest LSN in the set, LSN 80.

LSN 80  Undo the changes in P5.
        Append a CLR: Undo T1 LSN 80, set undonextLSN = 20.
        Add 20 to ToUndo.
        ToUndo consists of (60, 20).

LSN 60  Undo the changes on P2.
        Append a CLR: Undo T3 LSN 60, set undonextLSN = 40.
        Add 40 to ToUndo.
        ToUndo consists of (40, 20).

LSN 40  Undo the changes on P3.
        Append a CLR: Undo T3 LSN 40, T3 end.
        ToUndo consists of (20).

LSN 20  Undo the changes on P1.
        Append a CLR:
        Undo T1 LSN 20, T1 end
        ToUndo is now empty, Undo phase completes

e) The log looks like the following after recovery:

LSN 00  begin checkpoint
LSN 10  end checkpoint
LSN 20  update: T1 writes P1  prevLSN=null
LSN 30  update: T2 writes P2  prevLSN=null
LSN 40  update: T3 writes P3  prevLSN=null
LSN 50  T2 commit  prevLSN = 30
LSN 60  update: T3 writes P2  prevLSN = 40
LSN 70  T2 end  prevLSN = 50
LSN 80  update: T1 writes P5  prevLSN = 20
LSN 90  T3 abort  prevLSN = 60
LSN 100 CLR: Undo T1 LSN 80  undoNextLSN= 20
LSN 110 CLR: Undo T3 LSN 60  undoNextLSN= 40
LSN 120 CLR: Undo T3 LSN 40  undoNextLSN=null
LSN 125 T3 end
LSN 130 CLR: Undo T1 LSN 20  undoNextLSN=null
LSN 135 T1 end