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ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΡΗΤΗΣ

Συστήματα Διαχείρισης Βάσεων Δεδομένων

Φροντιστήριο 9: Transactions - part 1

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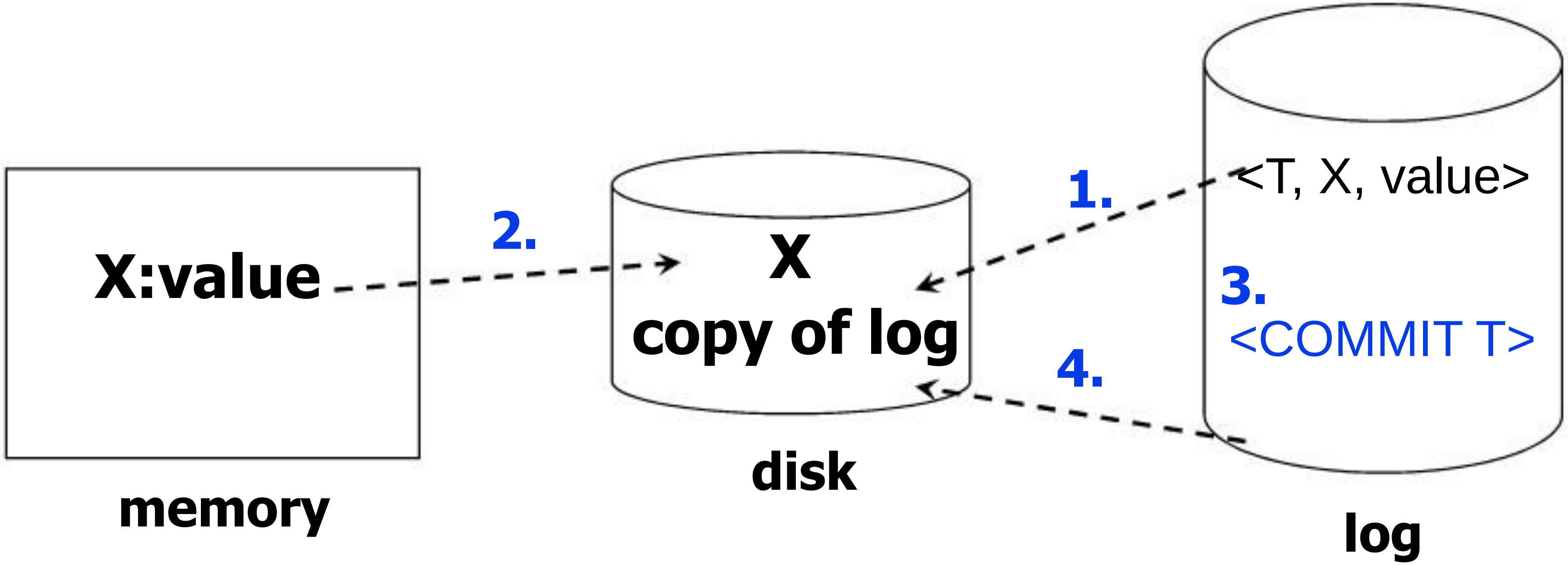
Τμήμα Επιστήμης Υπολογιστών

Tutorial on Undo, Redo and Undo/Redo Logging

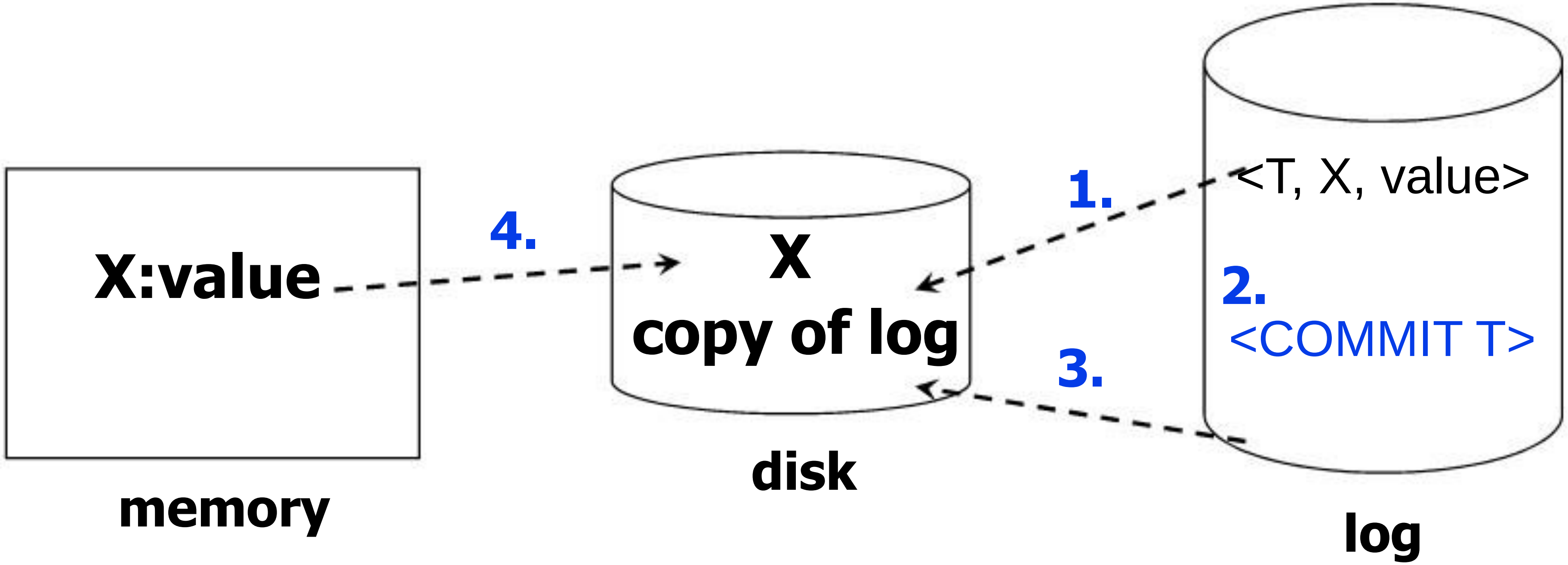
Quick Review: Undo vs. Redo Logging

- General Idea: In case of failure
  - Undo: cancels incomplete, ignores complete transactions
  - Redo: ignores incomplete, re-executes complete transactions
- Methodology: Undo



Quick Review: Undo vs. Redo Logging

- General Idea: In case of failure
  - Undo: cancels incomplete, ignores complete transactions
  - Redo: ignores incomplete, re-executes complete transactions
- Methodology: Redo



Quick Review: Undo vs. Redo Logging

- Checkpointing:

Undo:

1. Write <START CKPT (T_1,…,T_k)>
2. Flush the log.
3. Wait until all T_1,…T_k commit or abort.
4. Write <END CKPT>.
5. Flush the log.

Redo:

1. Write <START CKPT (T_1,…,T_k)>
2. Flush the log.
3. Write to disk all elements of transactions that had already committed before step 1.
4. Write <END CKPT>.
5. Flush the log.

Quick Review: Undo vs. Redo Logging

- Recovery:

Undo:

- Complete checkpoint: scan backwards as far as the START CKPT record.
- Incomplete checkpoint: scan backwards as far as the earliest of $T_1,\ldots T_k$.

Redo:

- Completed checkpoint: start scanning from the earliest of $T_1,\ldots T_k$.
- Incomplete checkpoint: search for previous complete checkpoint.

Example 1: Undo Recovery - Case 1

```
<START T1>
<T1, A, 5>
<START T2>
<T2, B, 10>
<START CKPT(T1,T2)>
<T2, C, 15>
<START T3>
<T1, D, 20>
<COMMIT T1>
<T3, E, 25>
<COMMIT T2>
<END CKPT>
→ <T3, F, 30>
```

- System crash after checkpoint
  - ■ Start scanning from the end.
  - ■ T3 is an incomplete transaction and must be undone. We set F = 30.
  - ■ We find an <END CKPT>. Therefore, we will stop scanning at the START CKPT.
  - ■ T2 committed. Do not touch!
  - ■ T3 incomplete. We set E = 25.
  - ■ No other transactions that started, but did not commit, until the START CKPT. End of scanning.

Example 1: Undo Recovery - Case 2

<START T1>
<T1, A, 5>
<START T2>
<T2, B, 10>
<START CKPT(T1,T2)>
<T2, C, 15>
<START T3>
<T1, D, 20>
<COMMIT T1>
→ <T3, E, 25>
<COMMIT T2>
<END CKPT>
<T3, F, 30>

- System crash during checkpoint
  - ■ Start scanning from the end.
  - ■ T3 incomplete. We set E = 25.
  - ■ T1 committed. Do not touch!
  - ■ T2 incomplete. We set C = 15.
  - ■ We find <START CKPT(T1,T2)>. The only possible incomplete are T1, T2. Still, T1 committed. Therefore, we continue until we meet <START T2>.
  - ■ T2 incomplete. We set B = 10.
  - ■ We meet <START T2>. End of scanning.

Example 1: Undo Recovery - Case 2 1/2

```
<START T1>
<T1, A, 5>
<START T2>
<T2, B, 10>
<START CKPT(T1,T2)>
<T2, C, 15>
<START T3>
<T1, D, 20>
<COMMIT T1>
<T3, E, 25>
<COMMIT T2>
<END CKPT>
<T3, F, 30>
```

- System crash during checkpoint
  - It is the same case as before.
  - We find <START CKPT(T1,T2)>. The only possible incomplete are T1, T2. Therefore, we continue until we meet all <START Ti>, where i = 1,2.

Example 2: Redo Recovery - Case 1

<START T1>

<T1, A, 5>

<START T2>

<COMMIT T1>

<T2, B, 10>

<START CKPT(T2)>

<T2, C, 15>

<START T3>

<T3, D, 20>

<END CKPT>

<COMMIT T2>

<COMMIT T3>

- System crash after checkpoint
  - ■ We make a quick scan from the end.
  - ■ We find <END CKPT> so we only need to care with those mentioned in the beginning record of the checkpoint and the ones started after that. That is T2, T3, and not T1.
  - ■ We start from the earliest transaction mentioned in the beginning record of the checkpoint and continue downwards.
  - ■ T2 committed, it must be redone. B = 10.
  - ■ T2 committed, it must be redone. C = 15.
  - ■ T3 committed, it must be redone. D = 20.

Example 2: Redo Recovery - Case 1 1/2

<START T1>

<T1, A, 5>

<START T2>

<COMMIT T1>

<T2, B, 10>

<START CKPT(T2)>

<T2, C, 15>

<START T3>

<T3, D, 20>

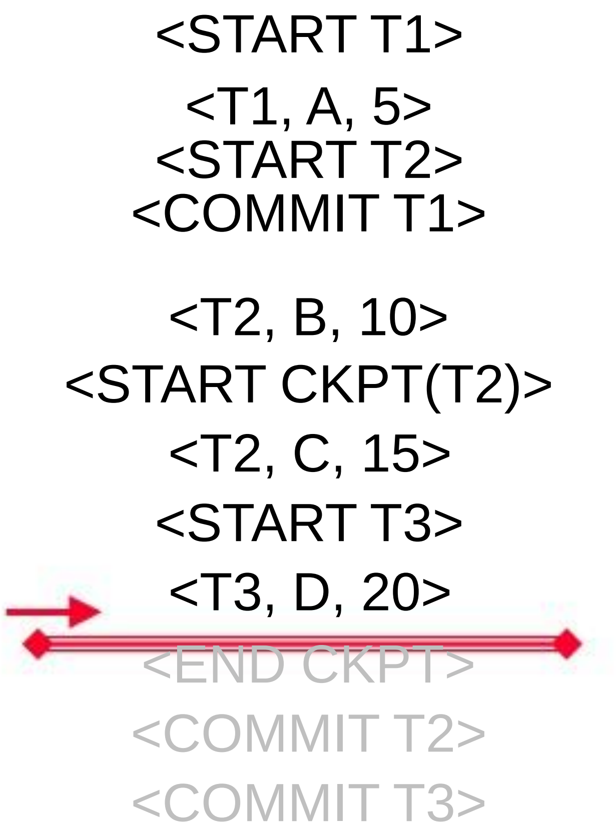
<END CKPT>

<COMMIT T2>

<COMMIT T3>

- System crash after checkpoint
  - ■ Now T3 is not a committed transaction and, as a result, we must not redo it.
  - ■ At the end of the recovery process, we add an <ABORT T3> record to the log.

Example 2: Redo Recovery - Case 2



<START T1>
<T1, A, 5>
<START T2>
<COMMIT T1>
<T2, B, 10>
<START CKPT(T2)>
<T2, C, 15>
<START T3>
<T3, D, 20>
<END CKPT>
<COMMIT T2>
<COMMIT T3>

- System crash during checkpoint
  - ■ We must search back to the previous checkpoint and find its list of active transactions.
  - ■ In this case there is no previous checkpoint. We start from the beginning of the log.
  - ■ Only T1 is committed and must be redone. A = 5.
  - ■ At the end of the recovery process, we add <ABORT T2>, <ABORT T3> to the log.

Example 3

```
<START T1>
<T1, C, 35>
<T1, D, 450>
<START T2>
<T2, C, 18>
<T2, B, 12>
<T1, D, 500>
<COMMIT T1>
<START CKPT (T2)>
<END CKPT>
<T2, D, 18>
<START T3>
<T3, C, 45>
<T3, E, 2>
<T2, A, 10>
<COMMIT T3>
<COMMIT T2>
```

- The following values are stored in the disk: A=10, B=12, C=45, D=65, E=2.
- Given the log shown
  - could this be an undo log?
  - No, because, for an undo log, all transactions mentioned at the start of the checkpoint must commit before its ending.
  - could this log result in the previously mentioned values for A, B, C, D and E?

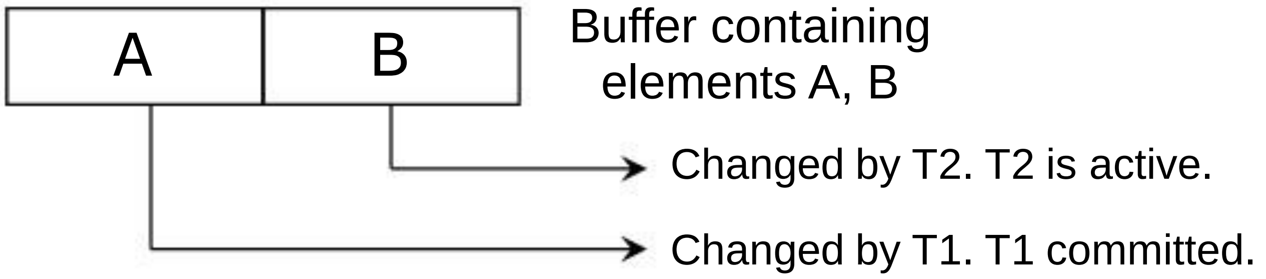
Example 4

```
<START T1>
<T1, C, 35>
<T1, D, 450>
<START T2>
<T2, C, 18>
<T2, B, 12>
<T1, D, 500>
<COMMIT T1>
<START CKPT (T2)>
<END CKPT>
<T2, D, 18>
<START T3>
<T3, C, 45>
<T3, E, 2>
<T2, A, 10>
<COMMIT T3>
<COMMIT T2>
```

- The following values are stored in the disk: A=10, B=12, C=45, D=65, E=2.
- Given the log shown
  - could this be a redo log?
  - Yes.
  - could this log result in the previously mentioned values for A, B, C, D and E?
  - No. The problem is the value of D. Since T1 committed before the checkpoint and is not mentioned as active, we are sure that D = 500 for the moment. T2 also accesses D. Maybe the changes were written or maybe not. In either case, D □ 65.

A Point of Caution

- What if the size of the elements are not equal to the size of memory buffers?
- For instance, if a buffer contains element A that was changed by a committed transaction and another element B that was changed by a transaction that has not yet had its COMMIT record written to disk.
- During checkpointing both undo and redo put contradictory requirements: the buffer must be copied to disk because of A, but also forbidden because of B.
- Solution: Undo/Redo Logging


A
B
Buffer containing elements A, B
Changed by T2. T2 is active.
Changed by T1. T1 committed.

Undo/Redo Logging

- Rule: Before modifying any element on disk, the log records must first be flushed.
- Checkpointing: Remember that we write an <END CKPT> only after all dirty buffers are written to disk (i.e., we flush all buffers, not just those written by committed transactions as in redo).
- Recovery: We proceed first backward to find checkpoints, forward to redo history and backward to undo uncommitted transactions, as appropriate.

Example 5: Undo/Redo Recovery - Case 1

```
<START T1>
<T1, A, 4, 5>
<START T2>
<COMMIT T1>
<T2, B, 9, 10>
<START CKPT(T2)>
<T2, C, 14, 15>
<START T3>
<T3, D, 19, 20>
<END CKPT>
<COMMIT T2>
<COMMIT T3>
```

- System crash after checkpoint
  - There is no need to look prior to the <START CKPT …> record
  - T1 is assumed completed and stored. We ignore it.
  - T2 and T3 are redone.

Example 5: Undo/Redo Recovery - Case 2

```
<START T1>
<T1, A, 4, 5>
<START T2>
<COMMIT T1>
<T2, B, 9, 10>
<START CKPT(T2)>
<T2, C, 14, 15>
<START T3>
<T3, D, 19, 20>
<END CKPT>
<COMMIT T2>
<COMMIT T3>
```

- System crash after checkpoint
  - As before but at the end we redo T2 and undo T3

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Ευρωπαϊκό Κοινωνικό Ταμείο

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2007-2013
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