Transaction Management
Recovery

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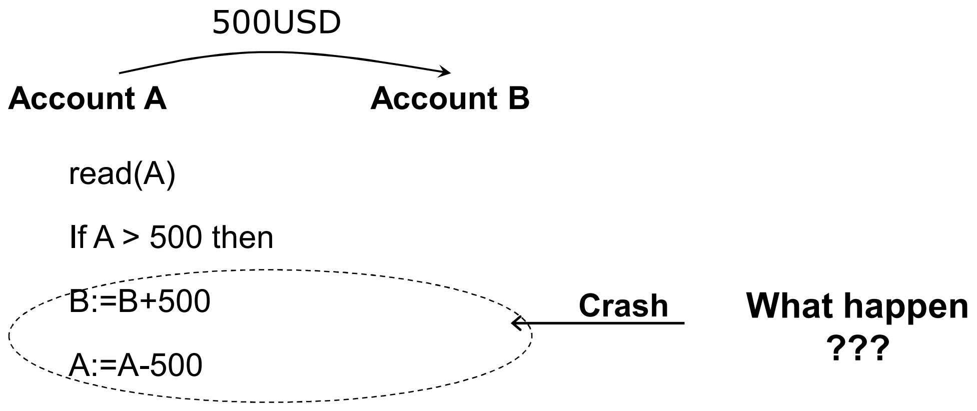
Learning objectives

- ***Upon completion of this lesson, students will be able to:***
    1. Understand recovery process
    2. Be able to select a suitable recovery strategy

Outline

1. Transaction and Recovery
2. Failure
3. Transaction Log
4. Checkpoint

Example



500USD

Account A **Account B**

read(A)

If A > 500 then

B:=B+500

A:=A-500

Crash

What happen ???

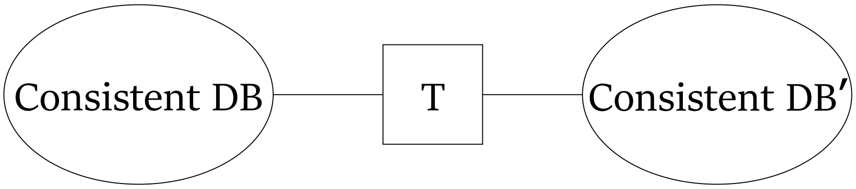
1. Transaction & Recovery

1.1. Objective

1.2. Problems

1.1. Objective

- Collection of action that preserve consistency


Consistent DB — T — Consistent DB′

with assumption

IF T starts with consistent state +
T executes in isolation

THEN T leaves consistent state

1.2. Problems

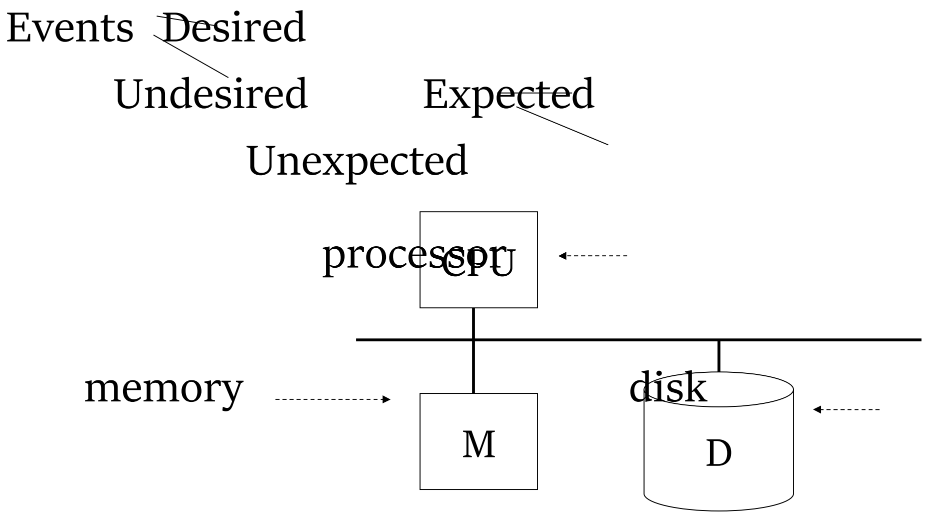
- Constraint violation?
  - Transaction bug
  - DBMS bug
  - Hardware failure
    - e.g., disk crash
  - Data sharing
    - e.g., T1 and T2 in parallel

2. Failures

2.1. Classification

2.2. How to do

2.1. Classification


Events Desired

Undesired Expected

Unexpected

processor

memory

disk

2.2. How to do

Failure ➔ recovery

- Maintaining the consistency of DB by ROLLBACK to the last consistency state.
- Ensuring 2 properties
  - Atomic
  - Durability

-> Using LOG

3. Transaction Log

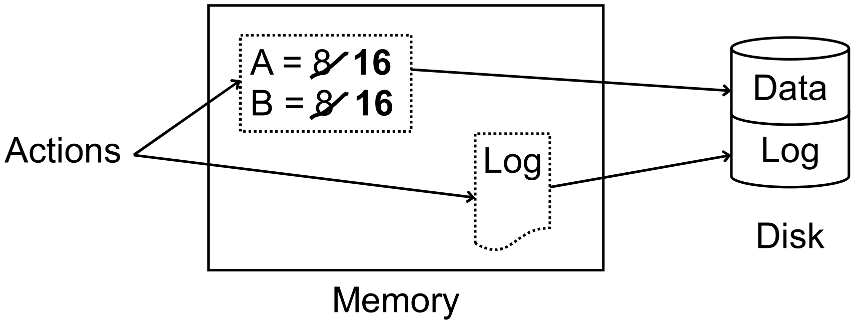
3.1. Log record
3.2. Undo logging
3.3. Redo logging
3.4. Discussion

3.1. Log record

- A sequence of log record keeping trace of actions executed by DBMS
  - <start T>
    - Log the beginning of the transaction execution
  - <commit T>
    - Transaction is already finished
  - <abort T>
    - Transaction is canceled
  - <T, X, v, w>
    - Transaction makes an update action, before update X=v, after update x = w

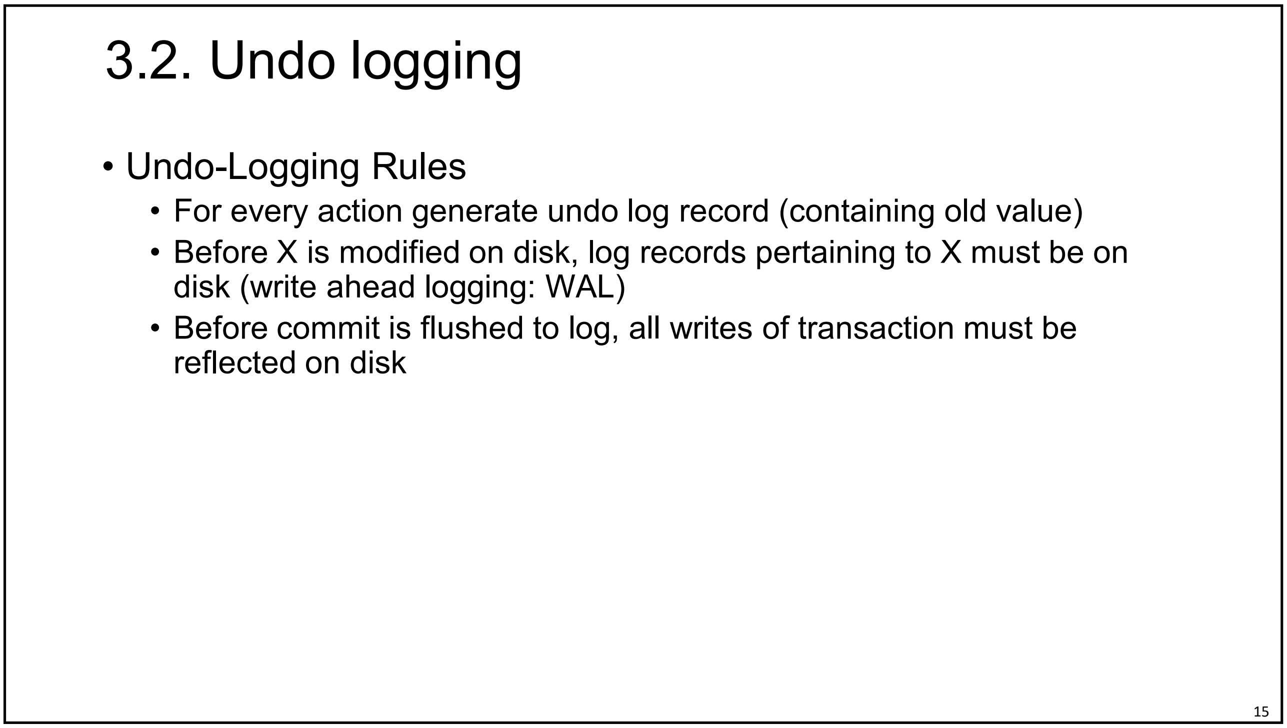
3.1. Log record

- Handled in main memory and put to external memory (disk) when possible



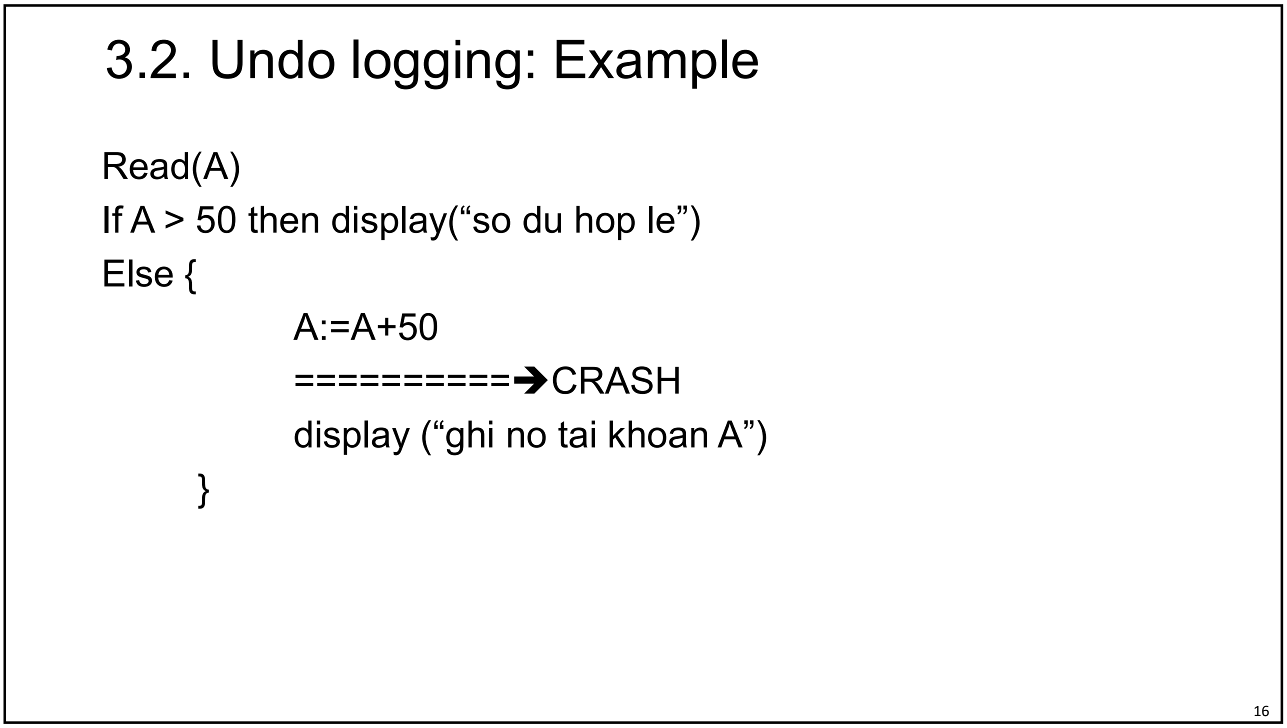
3.2. Undo logging

Step	Action	t	Mem A	Mem B	Disk A	Disk B	Mem Log
1							<start T>
2	Read(A,t)	8	8		8	8	
3	t:=t*2	16	8		8	8	
4	Write(A,t)	16	16		8	8	<T, A, 8>
5	Read(B,t)	8	16	8	8	8	
6	t:=t*2	16	16	8	8	8	
7	Write(B,t)	16	16	16	8	8	<T, B, 8>
8	**Flush log**						
9	Output(A)	16	16	16	16	8	
10	Output(B)	16	16	16	16	16	
11							<commit T>
12	**Flush log**						



3.2. Undo logging

- Undo-Logging Rules
  - For every action generate undo log record (containing old value)
  - Before X is modified on disk, log records pertaining to X must be on disk (write ahead logging: WAL)
  - Before commit is flushed to log, all writes of transaction must be reflected on disk



3.2. Undo logging: Example

```
Read(A)
If A > 50 then display(“so du hop le”)
Else {
            A:=A+50
            ==========➔CRASH
            display (“ghi no tai khoan A”)
      }
```

3.2. Undo logging: Recovery Rules

- Let S is set of unfinished transactions
  - <start T_i> in log
  - <commit T_i> or <abort T_i> is not in log

1

- For each <T_i, X, v> in log
  - If $T_i \in S$ then - Write(X, v)
    - Output(X)

2

- For each $T_i \in S$
  - Write <abort T_i> to log

3

3.3. Redo logging

Step	Action	t	Mem A	Mem B	Disk A	Disk B	Mem Log
1							<start T>
2	Read(A,t)	8	8		8	8	
3	t:=t*2	16	8		8	8	
4	Write(A,t)	16	16		8	8	<T, A, 16>
5	Read(B,t)	8	16	8	8	8	
6	t:=t*2	16	16	8	8	8	
7	Write(B,t)	16	16	16	8	8	<T, B, 16>
8							<commit T>
9	**Flush log**						
10	Output(A)	16	16	16	16	8	
11	Output(B)	16	16	16	16	16	
							<T, end>

3.3. Redo logging: Rules

1. For every action, generate redo log record (containing new value)
2. Before X is modified on disk (DB),all log records for transaction that modified X (including commit) must be on disk
3. Flush log at commit
4. Write END record after DB updates flushed to disk

3.3. Redo logging: Recovery Rules

- Let S = set of transactions with
  - <Ti, commit> in log
  - no <Ti, end> in log
- For each <Ti, X, w> in log, in forward order (earliest $\rightarrow$ latest)
  - If Ti $\in$ S then write(X, w)
    output(X)
- For each Ti $\in$ S
  - write <Ti, end>

3.4. Discussion

- Undo Logging
  - need to write to disk as soon transaction finishes
  - -> Access disk
- Redo Logging
  - need to keep all modified blocks in memory until commit
  - -> Use memory

3. Transaction Log

Undo/ Redo logging

Step	Action	t	Mem A	Mem B	Disk A	Disk B	Mem Log
1							<start T>
2	Read(A,t)	8	8		8	8	
3	t:=t*2	16	8		8	8	
4	Write(A,t)	16	16		8	8	<T, A, 8, 16>
5	Read(B,t)	8	16	8	8	8	
6	t:=t*2	16	16	8	8	8	
7	Write(B,t)	16	16	16	8	8	<T, B, 8, 16>
8	**Flush log**						
9	Output(A)	16	16	16	16	8	
10							<commit T>
11	Output(B)	16	16	16	16	16	

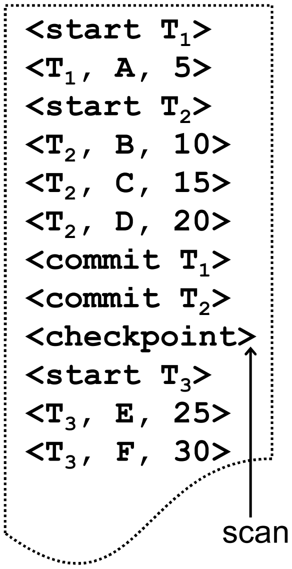
4. Checkpoint

4.1. Purpose
4.2. Checkpoint for Undo logging
4.3. Checkpoint for Redo logging
4.4 Checkpoint for Undo/Redo logging

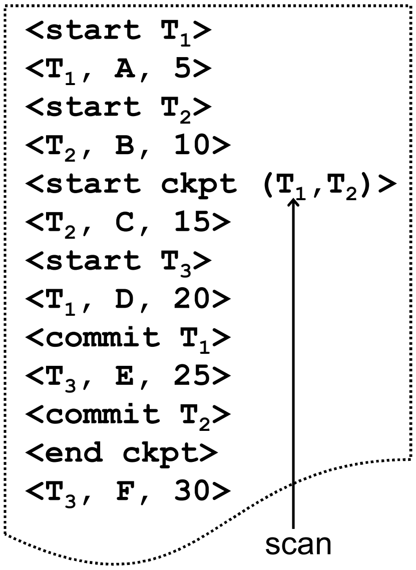
4.1. Purpose

- Decreases the amount of time required for data store recovery
- Makes a portion of the transaction log unneeded for any future data store recovery operation

4.2. Checkpoint for Undo Logging

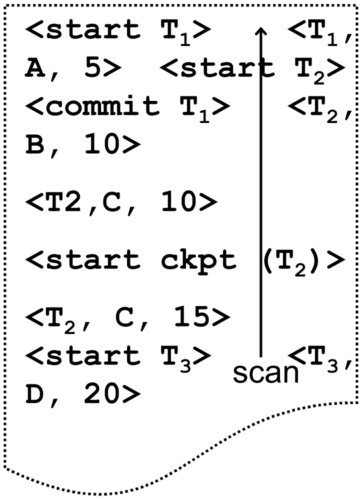


<start T_1>
<T_1, A, 5>
<start T_2>
<T_2, B, 10>
<T_2, C, 15>
<T_2, D, 20>
<commit T_1>
<commit T_2>
<checkpoint>
<start T_3>
<T_3, E, 25>
<T_3, F, 30>



<start T_1>
<T_1, A, 5>
<start T_2>
<T_2, B, 10>
<start ckpt (T_1,T_2)>
<T_2, C, 15>
<start T_3>
<T_1, D, 20>
<commit T_1>
<T_3, E, 25>
<commit T_2>
<end ckpt>
<T_3, F, 30>

4.3. Checkpoint for Redo Logging

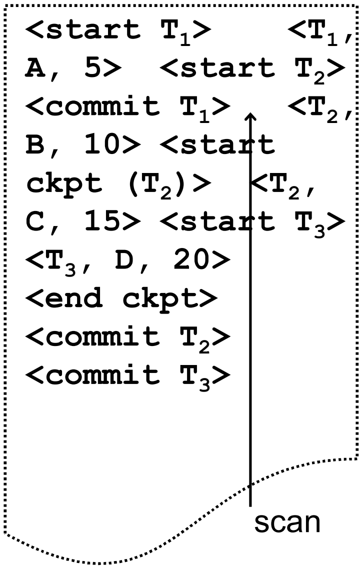


<start T_1> <T_1,
A, 5> <start T_2>
<commit T_1> <T_2,
B, 10>

<T2,C, 10>

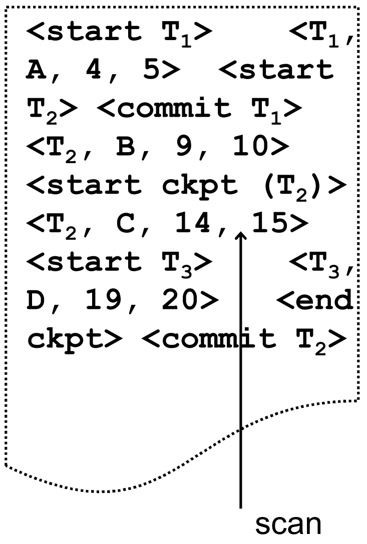
<start ckpt (T_2)>

<T_2, C, 15>
<start T_3> <T_3,
D, 20>



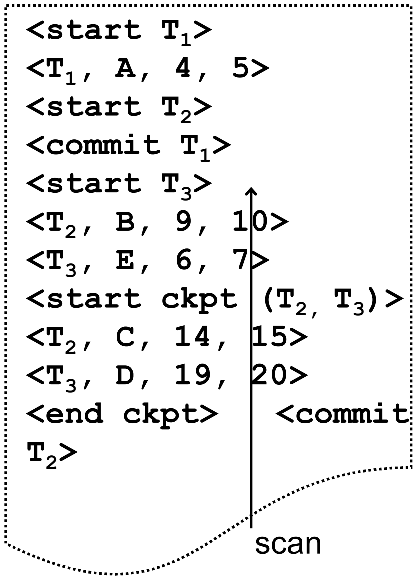
<start T_1> <T_1,
A, 5> <start T_2>
<commit T_1> <T_2,
B, 10> <start
ckpt (T_2)> <T_2,
C, 15> <start T_3>
<T_3, D, 20>
<end ckpt>
<commit T_2>
<commit T_3>

4.4. Checkpoint for Undo/Redo Logging



<start T_1> <T_1,
A, 4, 5> <start
T_2> <commit T_1>
<T_2, B, 9, 10>
<start ckpt (T_2)>
<T_2, C, 14, 15>
<start T_3> <T_3,
D, 19, 20> <end
ckpt> <commit T_2>

scan



<start T_1>
<T_1, A, 4, 5>
<start T_2>
<commit T_1>
<start T_3>
<T_2, B, 9, 10>
<T_3, E, 6, 7>
<start ckpt (T_2, T_3)>
<T_2, C, 14, 15>
<T_3, D, 19, 20>
<end ckpt> <commit
T_2>

scan

Summary

- Transaction
  - Sequence of actions
- Recovery
  - Maintaining the consistency of DB by ROLLBACK to the last consistency state.
- Logging
  - Sequence of record keeping trace of actions executed by DBMS
- Checkpoint
  - Provides a more up-to-date data store image on which recovery can begin