CMPT 321
FALL 2017

Transactions

Lecture 05.04

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Integrity or correctness of data

We would like data to be “accurate” or “correct” at all times

EMP table

Name	Age
White	52
Green	3421
Gray	1

Integrity or consistency constraints

- Predicates that data must satisfy

For example:

- x is key of relation R
- Domain(x) = {Red, Blue, Green}
- no employee should make more than twice the average salary

Definition:

- *Consistent state*: satisfies all constraints
- *Consistent DB*: DB in consistent state

Integrity constraints may not capture "full correctness"

Implicit (business) constraints:

- When salary is updated,

  new salary > old salary

- When account record is deleted,

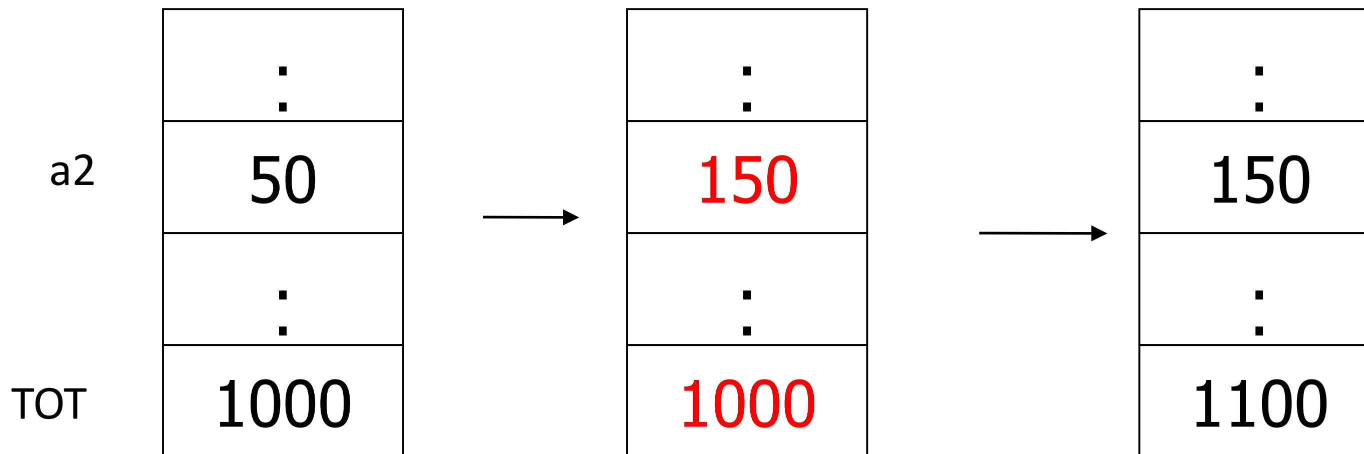
  balance = 0

Observation:
DB cannot be consistent always

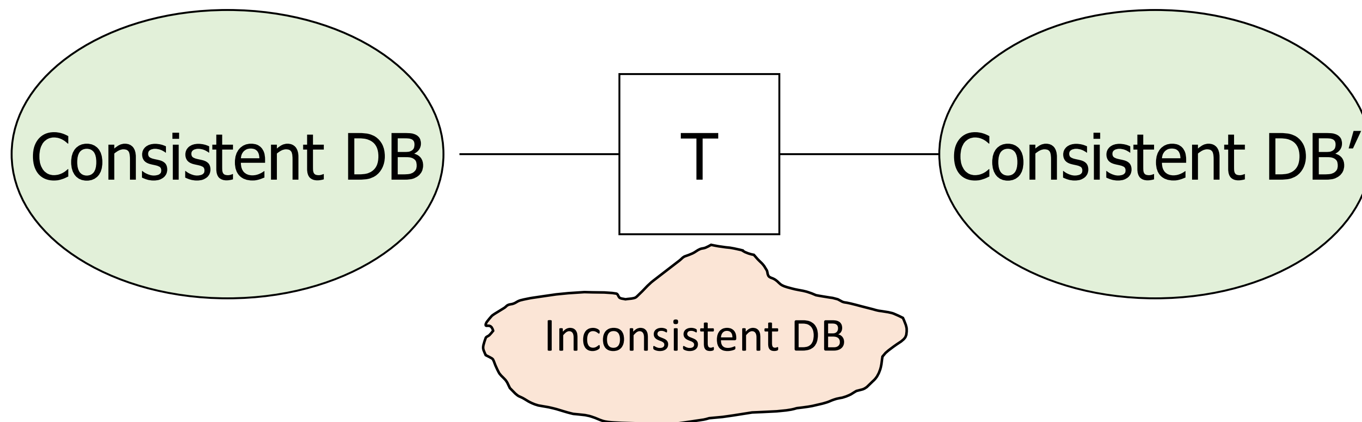
Example: $a1 + a2 + \ldots . \; an = TOT$ (constraint)

Deposit $100 in a2: $a2 \leftarrow a2 + 100$

$TOT \leftarrow TOT + 100$



Transaction: collection of actions that bring DB from one consistent state to another



If T starts with consistent state + T executes in isolation

$\Rightarrow$T leaves consistent state

Concurrent transactions

- In production environments, it is unlikely that we can limit our system to just one user at a time.
  - Consequently, it is possible for multiple queries to be submitted at approximately the same time.

- If all of the queries were very small (i.e., in terms of time), we could probably just execute them serially, on a first-come-first-served basis.

SERIALLY – ONE AFTER ANOTHER

Queries are executed “simultaneously”

- However, many queries are both complex and time consuming.
  - Executing these queries would make other queries wait a long time for a chance to execute.
  - Disk usage can be optimized for several queries running in parallel
- So, in practice, the DBMS may be running many different queries at about the same time.

INTERLEAVING QUERY PROCESSING

Concurrent Transactions

- Unlike operating systems, which *support* interaction of processes, a DMBS needs to keep processes from troublesome interactions.

- Even when there is **no "failure", several** transactions can **interact** to turn a
  consistent state
  into an
  inconsistent state.

Example: two people - one bank account

- Before withdrawing money, each needs to check if the balance is sufficient
- Initially there is **100**$ on the account

Ryan	Monica
READ(X, b)	
b=100	
	READ(X, c)
	c = 100
	c - = 50
	WRITE (X, c)
b - = **100**	
WRITE (X, Ryan)	

Monica: thinks 50 $ left

Ryan: thinks 0 $ left

In fact, the withdrawn amount is 150$

Example: two people - one bank account

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- Initially there is **100**$ on the account

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READ(X, b)	
b=100	
	READ(X, c)
	c = 100
	c - = 50
	WRITE (X, c)
b - = **100**	
WRITE (X, b)	

The problem is that the reading and writing operations should be performed as one ***transaction***, their combination should be **atomic**

Transaction

- DBMS groups your SQL statements into ***transactions***.
- The ***transaction*** is the atomic unit of execution of database operations
- By default, each query or DML statement is a transaction
- User can group multiple SQL statements into a single transaction

Transactions with SQL

START TRANSACTION; (BEGIN;)

…SQL statements

COMMIT; (END;)

End of a transaction

- The transaction ends when one of the following occurs:
  - A COMMIT or ROLLBACK are issued
  - A DDL (CREATE, ALTER, DROP …) or DCL (GRANT, REVOKE) statement is issued
  - A user properly exits (COMMIT)
  - System crashes (ROLLBACK)

COMMIT and ROLLBACK

- The SQL statement COMMIT causes a transaction to complete.
  - Its database modifications are now permanent in the database.

- The SQL statement ROLLBACK also causes the transaction to end, but by *aborting*.
  - No effects on the database.

- Failures like division by 0 or a constraint violation can also cause rollback, even if the programmer did not request it.

Banking example: DB terminal

Assuming we defined a CHECK constraint on balance >=0

Ryan

```
BEGIN;
 SELECT balance
 FROM accounts
 WHERE
 account_name = "Monica and Ryan";
 UPDATE accounts
 SET balance = balance – 100
 WHERE
 account_name = "Monica and Ryan";
COMMIT;
```

Monica

```
BEGIN;
 SELECT balance
 FROM accounts
 WHERE
 account_name = "Monica and Ryan";
 UPDATE accounts
 SET balance = balance – 50
 WHERE
 account_name = "Monica and Ryan";
COMMIT;
```

Failure – constraint violated

Transaction should have ACID

- ***A**tomicity*: Whole transaction or none is done.
- ***C**onsistency*: Database constraints preserved. Transaction, executed completely, takes database from one *consistent* state to another
- ***I**solation*: It appears to the user as if only one process executes at a time.
  - That is, even though actions of several transactions might be interleaved, the net effect is identical to executing all transactions one after another in some **serial order**.
- ***D**urability*: Effects of a process survive a crash.