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Database Systems I

Transaction Processing (1)

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Transaction

- A **transaction** is a sequence of one or more **operations** (reads or writes) which reflects **a single real-world transition**

- Examples
  - Transfer money between accounts
  - Purchase a group of products
  - Register for a class (waitlist or allocated)

Transactions (ACID)

Atomic
The all-or-nothing execution of transactions

Consistent
Transactions are expected to preserve the consistency and integrity of the database

Isolated
Transactions to be executed as if no other transaction is executing at the same time

Durable
Once a transaction has committed, its effects remain in the database

ACID: Atomic

- Transaction activities are atomic (**all or nothing**)
  - A transaction is something that would either occur completely or not at all

- Two possible outcomes for a transaction
  - It commits: all the changes are made
  - It aborts: no changes are made

Example

Accounts(acctNo, balance)

- Goal: Transferring $100 from the account numbered 123 to the account 456

Step(1)

```
UPDATE Accounts
SET balance = balance + 100 WHERE acctNo = 456;
```

Step(2)

```
UPDATE Accounts
SET balance = balance - 100 WHERE acctNo = 123;
```

- What happens if there is a failure after Step(1) but before Step(2)?

ACID: Consistent

- The tables must always satisfy user-specified **constraints**
  - Examples
    - Account number is unique
    - Stock amount cannot be negative
    - Sum of debits and of credits is 0

- How consistency is achieved?
  - Programmer makes sure a transaction takes a consistent state to a consistent state
  - System makes sure that the transaction is **atomic**

ACID: Isolated

- A transaction executes concurrently with other transactions

- **Isolation**: the effect is as if each transaction executes in isolation of the others
  - E.g. Should not be able to observe changes from other transactions during the run

Example

Flights(flightNo, flightDate, seatNo, seatStatus)

```
SELECT seatNo
FROM Flights
WHERE flightNo = 123 AND flightDate = DATE '2008-12-25'
AND seatStatus = 'available';
```

```
UPDATE Flights
SET seatStatus = 'occupied'
WHERE flightNo = 123 AND flightDate = DATE '2008-12-25'
AND seatNo = '22A';
```

- What happens if more than one person has the same request at the same time?
- **Serialization!**

ACID: Durable

- The effect of a transaction must continue to exist (**persist**) after the transaction
  - And after the whole program has terminated
  - And even if there are power failures, crashes, etc.
  - And …

- **Means:** Write data to **disk**

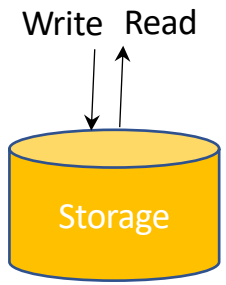
ACID

- Many debates over ACID, both **historically** and **currently**
- Many newer **NoSQL** DBMSs relax ACID

- In turn, now **NewSQL** reintroduces ACID compliance to NoSQL-style DBMSs

Transaction Management

Definition



Transaction = A list of writes and reads

For example: {Read, Read, Write}

Two Big Problems

1. Support multiple transaction at the same time
2. Make sure the data stored is reliable

Techniques

1. Concurrency Control
2. Database Recovery

Properties

Atomicity

Consistency

Isolation

Durability

Figure From Slides, CMPT 354: Database Systems I (Jiannan Wang - SFU), Fall 2018

Concurrency Control

- The DBMS must handle concurrency such that
  - **Isolation** is maintained
    - Users must be able to execute each transaction **as if they were the only user**
    - DBMS handles the details of interleaving various transactions
  - **Consistency** is maintained
    - Transactions must leave the DB in a **consistent state**
    - DBMS handles the details of enforcing integrity constraints

Interleaving

- Need to swap the control of transaction execution between multiple simultaneous transaction
  - Example
    - Execute few instructions from Transaction 1 and few instructions from Transaction 2
    - Again few more instructions from Transaction 1 and Transaction 2 and so on
- This is done for many simultaneous transactions
- This action is called as **interleaving of transactions**

Interleaving

- Interleaving transactions might lead to anomalous outcomes
  - **Why do we do it then?**

- Several important reasons: All concern large differences in **performance**
  - Individual transactions might be slow
    - Avoid blocking other users during slow transactions
  - Transactions waiting for locks
    - Avoid blocking other users while this transaction is also waiting
  - Disk access may be slow
    - Let some transactions use CPUs while others accessing disk

Scheduling

- A **serial schedule** is one that does not interleave the actions of different transactions

- A **serializable schedule** is a schedule that is equivalent to **some** serial schedule

- Two schedules are **equivalent** if, **for any database state**, the effect of executing them on the database **is identical**

Acknowledgements

I have used materials from the following resources in preparation of this course:

- **Database Systems: The Complete Book**
- Database Systems (Kifer, Bernstein, Lewis)
- Database System Concepts: https://www.db-book.com
- Course offerings
  - **CMPT 354 (Jiannan Wang - SFU): https://sfu-db.github.io/cmpt354/**
  - W 4111 (Eugene Wu - Columbia): https://w4111.github.io/
  - CS 245 (Matei Zaharia - Stanford): http://web.stanford.edu/class/cs245/
  - CS 186 (Joe Hellerstein - Berkeley): https://sites.google.com/site/cs186fall17/
  - CSE 344 (Dan Suciu - Washington): https://courses.cs.washington.edu/courses/cse344/17au/