Introduction to Data Management CSE 344

Lecture 20: More Transactions

Announcements

- HW7 (final one!) will be released today
  - Some Java programming required
  - Connecting to SQL Azure
  - Due Wednesday, March 8

- WQ7 (final one!) released
  - Due Monday, March 6

Outline

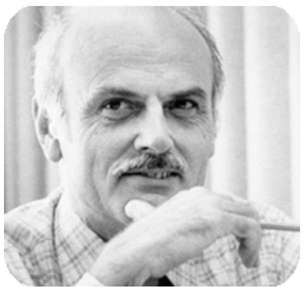
- Serial and Serializable Schedules (18.1)
- Conflict Serializability (18.2)
- Transaction implementation using locks (18.3)

Review: Transactions

- Problem: An application must perform *several* writes and reads to the database, as a unit
- Solution: multiple actions of the application are bundled into one unit called a *Transaction*

Turing Awards in Data Management

Charles Bachman, 1973
IDS and CODASYL



Ted Codd, 1981
Relational model

Jim Gray, 1998
Transaction processing

Michael Stonebraker, 2014
INGRES and Postgres

Review: Transactions in SQL

BEGIN TRANSACTION
[SQL statements]
COMMIT or
ROLLBACK (=ABORT)

[single SQL statement]

If BEGIN… missing,
then TXN consists
of a single instruction

Know your ~~chemistry~~ transactions: ACID

- Atomic
  - State shows either all the effects of txn, or none of them
- Consistent
  - Txn moves from a DBMS state where integrity holds, to another where integrity holds
    - remember integrity constraints?
- Isolated
  - Effect of txns is the same as txns running one after another (i.e., looks like batch mode)
- Durable
  - Once a txn has committed, its effects remain in the database

Atomic

- **Definition**: A transaction is ATOMIC if all its updates must happen or not at all.
- **Example**: move $100 from A to B
  - `UPDATE accounts SET bal = bal – 100 WHERE acct = A;`
  - `UPDATE accounts SET bal = bal + 100 WHERE acct = B;`
  - ```
    BEGIN TRANSACTION;
    UPDATE accounts SET bal = bal – 100 WHERE
    acct = A;
    UPDATE accounts SET bal = bal + 100 WHERE
    acct = B;
    COMMIT;
    ```
    ```

Isolated

- **Definition** An execution ensures that txns are isolated, if the effect of each txn is as if it were the only txn running on the system.

- More in a few slides

Consistent

- Recall: integrity constraints govern how values in tables are related to each other
  - Can be enforced by the DBMS, or ensured by the app
- How consistency is achieved by the app:
  - App programmer ensures that txns only takes a consistent DB state to another consistent state
  - DB makes sure that txns are executed atomically
- Can defer checking the validity of constraints until the end of a transaction

Durable

- A transaction is durable if its effects continue to exist after the transaction and even after the program has terminated
- How?
  - By writing to disk!
  - More in 444

Rollback transactions

- If the app gets to a state where it cannot complete the transaction successfully, execute ROLLBACK
- The DB returns to the state prior to the transaction
- What are examples of such program states?

Isolation: The Problem

- Multiple transactions are running concurrently $T_1, T_2, \ldots$
- They read/write some common elements $A_1, A_2, \ldots$
- How do we prevent unwanted interference?
- The SCHEDULER is responsible for that

Schedules

A **schedule** is a sequence of interleaved actions from all transactions

Review: Serial Schedule

- A *serial schedule* is one in which transactions are executed one after the other, in some sequential order

- Review: nothing can go wrong if the system executes transactions serially (up to what we have learned so far)
  - But DBMS don't do that because we want better overall system performance

Example

A and B are elements in the database
t and s are variables in txn source code

T1	T2
READ(A, t)	READ(A, s)
t := t+100	s := s*2
WRITE(A, t)	WRITE(A,s)
READ(B, t)	READ(B,s)
t := t+100	s := s*2
WRITE(B,t)	WRITE(B,s)

Example of a (Serial) Schedule

T1	T2
READ(A, t)	
t := t+100	
WRITE(A, t)	
READ(B, t)	
t := t+100	
WRITE(B,t)	
	READ(A,s)
	s := s*2
	WRITE(A,s)
	READ(B,s)
	s := s*2
	WRITE(B,s)

Time ↓

Another Serial Schedule

Time ↓

T1	T2
	READ(A,s)
	s := s*2
	WRITE(A,s)
	READ(B,s)
	s := s*2
	WRITE(B,s)
READ(A, t)	
t := t+100	
WRITE(A, t)	
READ(B, t)	
t := t+100	
WRITE(B,t)	

Review: Serializable Schedule

A schedule is serializable if it is equivalent to a serial schedule

A Serializable Schedule

T1	T2
READ(A, t)	
t := t+100	
WRITE(A, t)	
	READ(A,s)
	s := s*2
	WRITE(A,s)
READ(B, t)	
t := t+100	
WRITE(B,t)	
	READ(B,s)
	s := s*2
	WRITE(B,s)

This is a serializable schedule.
This is NOT a serial schedule

A Non-Serializable Schedule

T1	T2
READ(A, t)	
t := t+100	
WRITE(A, t)	
	READ(A,s)
	s := s*2
	WRITE(A,s)
	READ(B,s)
	s := s*2
	WRITE(B,s)
READ(B, t)	
t := t+100	
WRITE(B,t)	

How do We Know if a Schedule is Serializable?

Notation:

T_1: $r_1(A)$; $w_1(A)$; $r_1(B)$; $w_1(B)$
T_2: $r_2(A)$; $w_2(A)$; $r_2(B)$; $w_2(B)$

Key Idea: Focus on *conflicting* operations

Conflicts

- Write-Read – WR
- Read-Write – RW
- Write-Write – WW
- Read-Read?

Conflict Serializability

Conflicts: (i.e., swapping will change program behavior)

Two actions by same transaction T_i: $r_i(X); w_i(Y)$

Two writes by T_i, T_j to same element $w_i(X); w_j(X)$

Read/write by T_i, T_j to same element $w_i(X); r_j(X)$

$r_i(X); w_j(X)$

Conflict Serializability

- A schedule is *conflict serializable* if it can be transformed into a serial schedule by a series of swappings of adjacent non-conflicting actions

- Every conflict-serializable schedule is serializable

Conflict Serializability

Example:

$r_1(A); w_1(A); r_2(A); w_2(A); r_1(B); w_1(B); r_2(B); w_2(B)$

Conflict Serializability

Example:

$r_1(A); w_1(A); r_2(A); w_2(A); r_1(B); w_1(B); r_2(B); w_2(B)$

⇩

$r_1(A); w_1(A); r_1(B); w_1(B); r_2(A); w_2(A); r_2(B); w_2(B)$