Data Storage and Retrieval

Lecture 9

Transactions and Views

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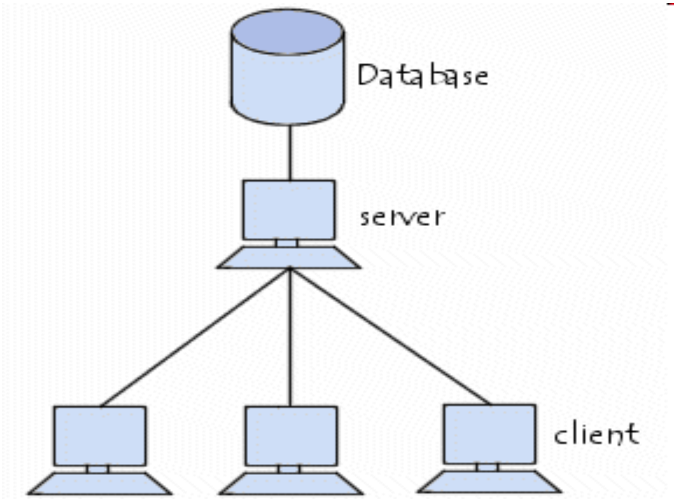
Why Transactions?

- Database systems are normally being accessed by many users or processes at the same time.
  - Both queries and modifications.

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

Controlled Concurrent Access

- Databases can have many users reading and writing at the same time



- We need to make sure that each view of the data is correct or consistent for each user
  - So that concurrent access does not cause incorrect updates

Example: Bad Interaction

- Imagine a bank's database of accounts

Customer	Balance (£)
Mr & Mrs Bloggs	100
…	…

- And the operation to withdraw £10 from a cash machine:

```
X = Get_balance();
Set_balance(X-10);
```

- Now what happens if Mr & Mrs Bloggs both withdraw £10 concurrently, i.e. at exactly the same time?

Example: Bad Interaction

Customer	Balance (£)
Mr & Mrs Bloggs	90
…	…

Mr Bloggs 

```
X = Get_balance();
```

X=100

```
Set_balance(X-10);
```

Mrs Bloggs 

```
X = Get_balance();
```

X=100

```
Set_balance(X-10);
```

- Here, concurrent access resulted in an incorrect account balance being recorded

Controlled Concurrent Access

- Databases can have many users reading and writing at the same time
    - We need to make sure that each view of the data is correct or consistent for each user
    - So that concurrent access does not cause incorrect updates
- DBMS have concurrent control software to ensure that several users updating the same data do so in a controlled manner
- This happens through transactions, which make concurrent database interactions appear to happen independently & sequentially

Transactions

- *Transaction* = process involving database queries and/or modification.

- Normally with some strong properties regarding concurrency.
- Formed in SQL from single statements or explicit programmer control.

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ACID Transactions

- *ACID transactions* are:
  - *Atomic* : Whole transaction or none is done.
  - *Consistent* : Database constraints preserved.
  - *Isolated* : It appears to the user as if only one process executes at a time.
  - *Durable* : Effects of a process survive a crash.

- Optional: weaker forms of transactions are often supported as well.

Transaction Operations

- An DBMS keeps track of when a transaction starts, terminates, and commits or aborts.
- To do this, a recovery manager process tracks the following operations:
  - BEGIN_TRANSACTION
  - READ or WRITE
  - END_TRANSACTION
  - COMMIT_TRANSACTION
  - ROLLBACK

COMMIT

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

ROLLBACK

- 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 does not request it.

Example: Interacting Processes

- Assuming the relation Sells(bar,beer,price), and suppose that Joe's Bar sells only 2 beers:
  - Bud for £2.50 and
  - Miller for £3.00.

- Sally is querying Sells for the highest and lowest price Joe charges.
- Joe decides to stop selling Bud and Miller, but to sell only Heineken at £3.50.

Sally's Program

- Sally executes the following two SQL statements called (min) and (max):

```
(max) SELECT MAX(price) FROM Sells
                 WHERE bar = 'Joe's Bar';

(min)  SELECT MIN(price) FROM Sells
                 WHERE bar = 'Joe's Bar';
```

Joe's Program

- At about the same time, Joe executes the following steps: (del) and (ins).

```
(del)   DELETE FROM Sells
        WHERE bar = 'Joe's Bar';
(ins)   INSERT INTO Sells
        VALUES('Joe's Bar', 'Heineken', 3.50);
```

Interleaving of Statements

- Although (max) must come before (min), and (del) must come before (ins), there are no other constraints on the order of these statements
- Unless, we group Sally's and/or Joe's statements into transactions.

Example: Strange Interleaving

- Suppose the steps execute in the order (max)(del)(ins)(min).

Joe's Prices:	{2.50,3.00}	{2.50,3.00}		{3.50}
Statement:	(max)	(del)	(ins)	(min)
Result:	3.00			3.50

- Sally sees MAX < MIN!

Fixing the Problem with Transactions

- If we group Sally's statements (max)(min) into one transaction, then she cannot see this inconsistency.
- She sees Joe's prices at some fixed time.
  - Either before or after he changes prices, or in the middle, but the MAX and MIN are computed from the same prices.

Another Problem: Rollback

- Suppose Joe executes (del)(ins), not as a transaction, but after executing these statements, thinks better of it and issues a ROLLBACK statement.
- If Sally executes her statements after (ins) but before the rollback, she sees a value, 3.50, that never existed in the database.

Solution

- If Joe executes (del)(ins) as a transaction, its effect cannot be seen by others until the transaction executes COMMIT.
  - If the transaction executes ROLLBACK instead, then its effects can *never* be seen.

Isolation Levels

- SQL defines four *isolation levels*
  - READ_UNCOMMITTED
  - READ_COMMITTED
  - REPEATABLE_READ
  - SERIALIZABLE

- Isolation levels are choices about what interactions are allowed by transactions that execute at about the same time.

Isolation Levels

- Only the “serializable” level = ACID transactions.
- Each DBMS implements transactions in its own way.

Choosing the Isolation Level

- Within a transaction, we can say:

SET TRANSACTION ISOLATION LEVEL *X*

where *X* =

1. SERIALIZABLE
2. REPEATABLE READ
3. READ COMMITTED
4. READ UNCOMMITTED

Serializable Transactions

- If Sally = (max)(min) and Joe = (del)(ins) are each transactions, and Sally runs with isolation level SERIALIZABLE:
- Sally will see the database either before or after Joe runs, but not in the middle.

Isolation Level Is Personal Choice

- Your choice, e.g., run serializable, affects only how *you* see the database, not how others see it.

- Example: If Joe Runs serializable, but Sally doesn't, then Sally might see no prices for Joe's Bar.
  - i.e., it looks to Sally as if she ran in the middle of Joe's transaction.

Read-Commited Transactions

- If Sally runs with isolation level READ COMMITTED, then she can see only committed data, but not necessarily the same data each time.

- Example: Under READ COMMITTED, the interleaving (max)(del)(ins)(min) is allowed.
  - **As long as Joe commits,** Sally sees MAX < MIN.

Repeatable-Read Transactions

- Repeatable-read is like read-committed, plus:

- If data is read again, then everything seen the first time will be seen the second time.
  - But the second and subsequent reads may see *more* tuples as well.

Example: Repeatable Read

- Suppose Sally runs under REPEATABLE READ, and the order of execution is (max)(del)(ins)(min).
  - (max) sees prices 2.50 and 3.00.
  - (min) can see 3.50, but must also see 2.50 and 3.00, because they were seen on the earlier read by (max).

Read Uncommitted

- A transaction running under READ UNCOMMITTED can see data in the database, even if it was written by a transaction that has not committed (and may never).
- Example: If Sally runs under READ UNCOMMITTED, she could see a price 3.50 even if Joe later aborts.

Views

- A *view* is a relation defined in terms of stored tables (called *base tables*) and other views.

- There are two kinds of views:
  1. *Virtual* = not stored in the database; just a query for constructing the relation.
  2. *Materialized* = actually constructed and stored.

Declaring Views

- Declare by:

  CREATE [MATERIALIZED] VIEW <name> AS <query>;

- Default is virtual.

Example: View Definition

- CanDrink(drinker, beer) is a view "containing" the drinker-beer pairs such that the drinker frequents at least one bar that serves the beer:

```
CREATE VIEW CanDrink AS
    SELECT drinker, beer
    FROM Frequents, Sells
    WHERE Frequents.bar = Sells.bar;
```

Example: Accessing a View

- Query a view as if it were a base table.
  - Also: a limited ability to modify views if it makes sense as a modification of one underlying base table.

- Example query:

```
SELECT beer FROM CanDrink
WHERE drinker = 'Sally';
```

Triggers on Views

- Generally, it is impossible to modify a virtual view, because it doesn't exist.
- But an INSTEAD OF trigger lets us interpret view modifications in a way that makes sense.
- Example: View Synergy has (drinker, beer, bar) triples such that the bar serves the beer, the drinker frequents the bar and likes the beer.

Example: The View

Pick one copy of each attribute

```
CREATE VIEW Synergy AS
  SELECT Likes.drinker, Likes.beer, Sells.bar
  FROM Likes, Sells, Frequents
  WHERE Likes.drinker = Frequents.drinker
        AND Likes.beer = Sells.beer
        AND Sells.bar = Frequents.bar;
```

Natural join of Likes, Sells, and Frequents

Interpreting a View Insertion

- We cannot insert into Synergy --- it is a virtual view.
- But we can use an INSTEAD OF trigger to turn a (drinker, beer, bar) triple into three insertions of projected pairs, one for each of Likes, Sells, and Frequents.
  - Sells.price will have to be NULL.

The Trigger

```
CREATE TRIGGER ViewTrig
  INSTEAD OF INSERT ON Synergy
  REFERENCING NEW ROW AS n
  FOR EACH ROW
  BEGIN
        INSERT INTO LIKES VALUES(n.drinker, n.beer);
        INSERT INTO SELLS(bar, beer) VALUES(n.bar, n.beer);
        INSERT INTO FREQUENTS VALUES(n.drinker, n.bar);
  END;
```

Materialized Views

- **Problem**: each time a base table changes, the materialized view may change.
  - Cannot afford to recompute the view with each change.

- **Solution**: Periodic reconstruction of the materialized view, which is otherwise "out of date."

Example: Mailing List

- The mailing list of the (fictional) class cs1Q is a materialized view of the class enrollment in the DBMS.

- It is updated four times a day.
  - You can enroll and miss an email sent out after you enroll.

Example: A Data Warehouse

- A retailer stores every sale at every store in a database.
- Overnight, the sales for the day are used to update a *data warehouse*
- The data warehouse is in effect materialized views of the sales.
- The warehouse is used by analysts to predict trends and move goods to where they are selling best.