Introduction to Data Management
CSE 344

Lecture 20: Introduction to Transactions

Announcements

- WQ6 due tonight.
- HW6 due tomorrow.
- WQ 7 due next Monday
- HW7 (transactions) will be out Wednesday
  - Due next Thursday (Aug 10)

Schema Refinements = Normal Forms

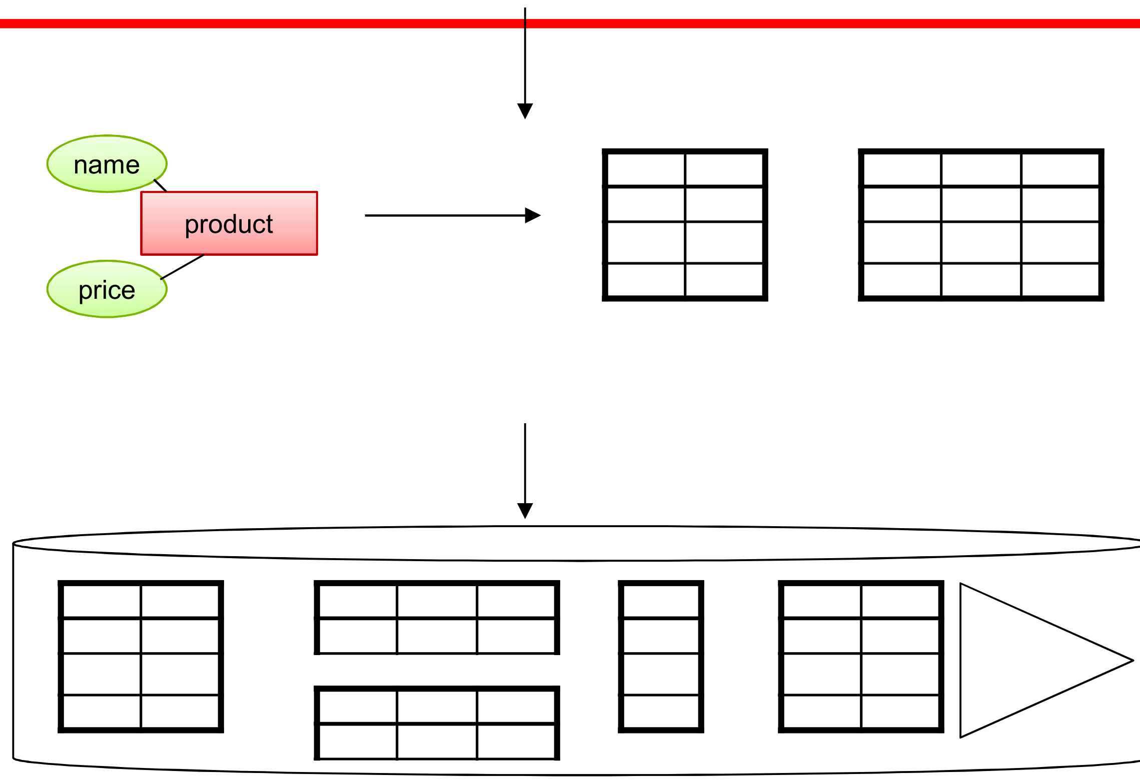
- 1st Normal Form = all tables are flat
- 2nd Normal Form = obsolete
- Boyce Codd Normal Form = no bad FDs
- 3rd and 4th Normal Form = see book
  - BCNF is lossless but can cause loss of ability to check some FDs (see book 3.4.4)
  - 3NF fixes that (is lossless and dependency-preserving), but some tables might not be in BCNF – i.e., they may have redundancy anomalies
  - 4NF deals with multi-valued dependencies (see book 3.6)

Data Management Pipeline

Application programmer

Schema designer

Conceptual Schema



Database administrator

Physical Schema

Transactions

- We use database transactions everyday
  - Bank $$$ transfers
  - Online shopping
  - Signing up for classes

- For this class, a transaction is a series of DB queries
  - Read / Write / Update / Delete / Insert
  - Unit of work issued by a user that is independent from others

What's the big deal?

Demo
(see lec20-transactions-intro.sql)

Challenges

- Want to execute many apps concurrently
  - All these apps read and write data to the same DB

- Simple solution: only serve one app at a time
  - What's the problem? Batch mode

Slow

- Want: multiple operations to be executed *atomically* over the same DBMS

What can go wrong?

- Manager: balance budgets among projects
  - Remove $10k from project A
  - Add $7k to project B
  - Add $3k to project C
- CEO: check company's total balance
  - SELECT SUM(money) FROM budget;
- This is called a dirty / inconsistent read aka a WRITE-READ conflict

What can go wrong?

- App 1:
  SELECT inventory FROM products WHERE pid = 1

- App 2:
  UPDATE products SET inventory = 0 WHERE pid = 1

- App 1:
  SELECT inventory * price FROM products
  WHERE pid = 1

  need to be same as first results

- This is known as an unrepeatable read
  aka READ-WRITE conflict

What can go wrong?

Account 1 = $100
Account 2 = $100
Total = $200

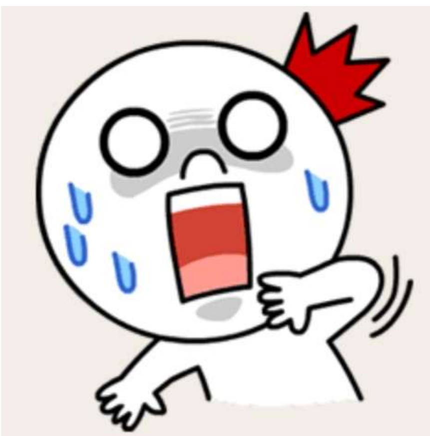
- App 1:
  - Set Account 1 = $200
  - Set Account 2 = $0
- App 2:
  - Set Account 2 = $200
  - Set Account 1 = $0
- At the end:
  - Total = $200

- App 1: Set Account 1 = $200
- App 2: Set Account 2 = $200
- App 1: Set Account 2 = $0
- App 2: Set Account 1 = $0
- At the end:
  - Total = $0

This is called the lost update aka WRITE-WRITE conflict

What can go wrong?

- Buying tickets to a Sounders game:
  - Fill up form with your mailing address
  - Put in debit card number
  - Click submit
  - Screen shows money deducted from your account
  - [Your browser crashes]



Lesson:

Changes to the database should be ALL or NOTHING

Transactions

- Collection of statements that are executed atomically (logically speaking)

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

-Undo

update acc 1
update acc 2

```
[single SQL statement]
```

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

More Transactions Demo

Serial execution

- **Definition**: A SERIAL execution of transactions is one where each transaction is executed one after another.

- **Fact**: Nothing can go wrong if the DB executes transactions serially
  - (Up to everything that we have learned so far)

- **Definition**: A SERIALIZABLE execution of transactions is one that is equivalent to a serial execution

What we want: 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;

atomic

  - 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.

Should look like batch mode

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?

write-write or others

ACID

- Atomic
- Consistent
- Isolated
- Durable

- Enjoy this in HW7!

- Again: by default each statement is its own txn
  - Unless auto-commit is off then each statement starts a new txn

Implementation of transactions

- sqlite: single lock for the entire DB
  - http://www.sqlite.org/atomiccommit.html
  - Not true for SQL Server, DB2, etc

SQLite Transactions

- **Step 1**: When txn starts: acquires a read lock (aka shared lock) (recall CSE 332?)
- **Step 2**: When txn writes: acquire a reserved lock
- **Step 3**: When txn commits:
  - First acquire a pending lock: no new read locks allowed
  - Wait until all current read locks are released
  - Acquire an exclusive lock
  - Make updates to DB on disk
  - Commit, release all locks