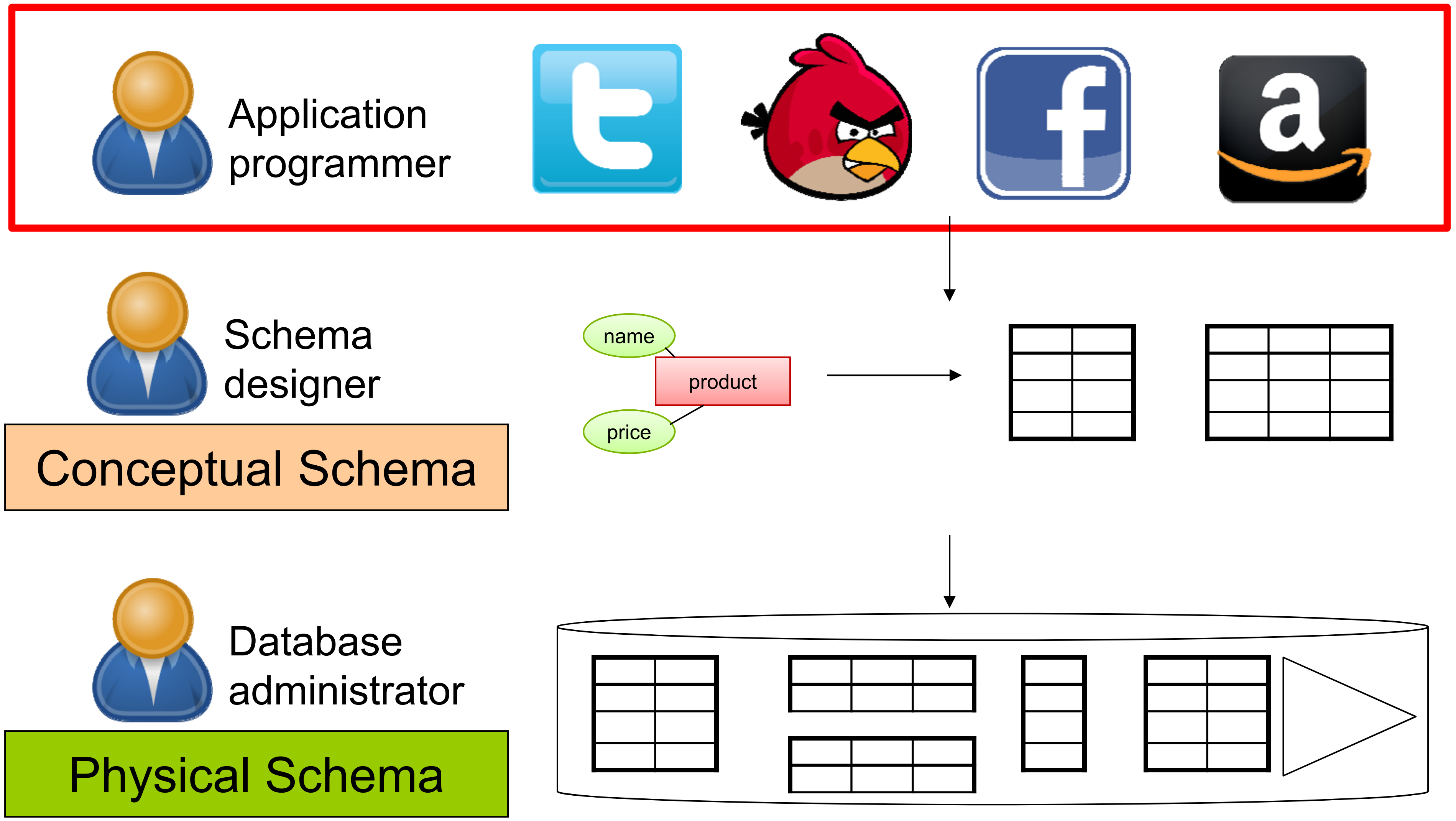
Database Systems CSE 414

Lecture 25: Introduction to Transactions (Ch 8.1)

Announcements

- WQ6 is due tomorrow 11pm
- HW7 is due on Friday 11pm
- WQ7 is posted and due on Dec. 7th, 11pm

Data Management Pipeline



Demo

(see lec25-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?
- Better: multiple operations need to be executed *atomically* over the DB

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 a.k.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
- This is known as an unrepeatable read a.k.a.
  READ-WRITE conflict

What can go wrong?

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

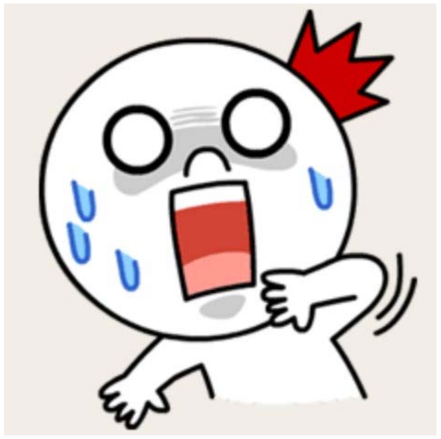
- App 1:
  - Set Account 1 = $200
  - Set Account 2 = $0
- App 2:
  - Set Account 2 = $200
  - Set Account 1 = $0
- At the end:
  - Total = $200

- 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 a.k.a. WRITE-WRITE conflict

What can go wrong?

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



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)
```

```
[single SQL statement]
```

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

Transactions Demo
(see lec25-transactions-intro.sql)

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

ACID Transactions

- Atomic
  - State shows either all the effects of txn, or none of them
- Consistent
  - Txn moves from a state where integrity holds, to another where integrity holds
- 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;
```

Crash!

```
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.
- **Example**: Alice deposits $100, Bob withdraws $100 from account

Alice:

```
BEGIN TRANSACTION;
x = select bal from accounts
      where acct = A;
x = x+100
update accounts
   set bal = x where acct = A;
COMMIT;
```

Bob:

```
BEGIN TRANSACTION;
y = select bal from accounts
      where acct = A;
if y < 100 return “Error”
y = y - 100
update accounts
   set bal = y where acct = A;
COMMIT;
```

Consistent

- Recall: integrity constraints govern how values in tables are related to each other
  - Example: account.bal >= 0
  - Example: foreign key constraints
- Can be enforced by the DBMS or 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
  – (often multiple disks, since individual disks can fail)

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

ACID

- Atomic
- Consistent
- Isolated
- Durable

- Enjoy this in HW8!

- Note: by default, each statement is its own txn
  - Exception: if auto-commit is off, then every statement immediately after a commit starts a new txn and each subsequent statement is contained within the same txn until the txn commits

Transactions

Jim Gray

- Inventor of ACID transactions, 2PL, data cubes, ...
- Joined Microsoft in 1995
- Won the Turing Award in 1998
- His book “Transaction Processing” is probably still the best work on database implementation