Introduction to Database Systems

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Database

What is a database?

- Physical storage: A collection of files storing related data.
- Logical: A collection of tables (or objects).

Examples of databases

- Accounts database; payroll database; SMU’s students database; Amazon’s products database; airline reservation database.
Database Management System

What is a DBMS?

- A complicated (and often expensive) piece of software typically running on a large (remote) server written by someone else that allows us to manage efficiently a large database and allows it to persist over long periods of time.

Examples of DBMS

- Commercial: DB2 (IBM), SQL Server (MS), Oracle, Sybase
- Open Source: MySQL, Postgres, SQLite, ...
- Big Data: often NoSQL like MongoDB, Apache Cassandra, etc.
Architecture: Using a DMBS

“Client-server Architecture”

Data files

Database server running the DBMS

connection

(ODBC, JDBC)

Applications running a client
Operations: Query/Update

Assume we have a database for movies and actors.

- Simple query:
  In what year was ‘Star Wars’ produced?

- Multi-table query:
  Find all movies with ‘Harrison Ford’
  (combine actor and movie tables)

- Complex query:
  For each actor, count her/his movies

- Updating
  Insert a new movie;
  add an actor to a movie; etc
Operations: Query/Update

- Files (e.g., CSV) - Simple queries
- Spreadsheets - Multi-table queries (maybe)
- DBMS - All

Updates: generally OK
Change the Structure of a DB

Add *Address* to each Actor

- Files (e.g., CSV) → Very hard
- Spreadsheets → Yes
- DBMS → Yes
Issue: Concurrent Access

Multiple users access/update the data concurrently

• What can go wrong?
  Lost update; resulting in inconsistent data
• How do we protect against that in OS?
  Locks
• Databases need a similar concept to deal with concurrent updates.
Issue: Recover from crashes

- Transfer $100 from account #4662 to #7199:

  X = Read(Accounts, 4662);
  X.amount = X.amount - 100;
  Write(Accounts, 4662, X);

  Y = Read(Accounts, 7199);
  Y.amount = Y.amount + 100;
  Write(Accounts, 7199, Y);

CRASH!

What is the problem?
Concurrency & Recovery: Transactions

- A transaction = sequence of statements that either all succeed, or all fail together.
- E.g., Transfer $100

```
BEGIN TRANSACTION;

UPDATE Accounts
SET amount = amount - 100
WHERE number = 4662

UPDATE Accounts
SET amount = amount + 100
WHERE number = 7199

COMMIT
```

```
BEGIN TRANSACTION;

UPDATE Accounts
SET amount = amount - 100
WHERE number = 4662

UPDATE Accounts
SET amount = amount + 100
WHERE number = 7199

COMMIT
```
Transactions

Transactions have the ACID properties:

- **A** = atomicity
- **C** = consistency
- **I** = isolation
- **D** = durability

Transactions also allow rollbacks (undo).
Relational Data Base
= Collection of Tables

**Actors:**

<table>
<thead>
<tr>
<th>id</th>
<th>fName</th>
<th>lName</th>
</tr>
</thead>
<tbody>
<tr>
<td>15901</td>
<td>Harrison</td>
<td>Ford</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Movie_Actors:**

<table>
<thead>
<tr>
<th>id</th>
<th>mid</th>
</tr>
</thead>
<tbody>
<tr>
<td>15901</td>
<td>130128</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

**Movies:**

<table>
<thead>
<tr>
<th>mid</th>
<th>Title</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>130128</td>
<td>Star Wars</td>
<td>1977</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Create/Store Large Datasets

Use SQL to create and populate tables:

```sql
CREATE TABLE Actors ( fName CHAR(30), lName CHAR(30), . . . )
INSERT INTO Actors VALUES('Harrison', 'Ford', . . . )
```

Physical organization of the data is handled by DBMS

We focus on modeling the database!
Querying

• Find all movies with ‘Harrison Ford’

```sql
SELECT title
FROM Movies, Actors, Movie_Actors
WHERE Actors.lname = 'Ford' and
    Actors.fname = 'Harrison' and
    Movies.mid = Movie_Actors.mid and
    Movie_Actors.id = Actors.id
```

• What happens behind the scene?
  The DBMS uses indices and optimizes automatically the query...
Add *Address* to each Actor

```sql
ALTER TABLE Actor
ADD address CHAR(50)
DEFAULT 'unknown'
```
What comes next?

1) Using a DBMS
2) Using SQL Query Databases
3) Designing a Database