Introduction to Database Systems

Based on slides by Dan Suciu

Adapted by Michael Hahsler

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?

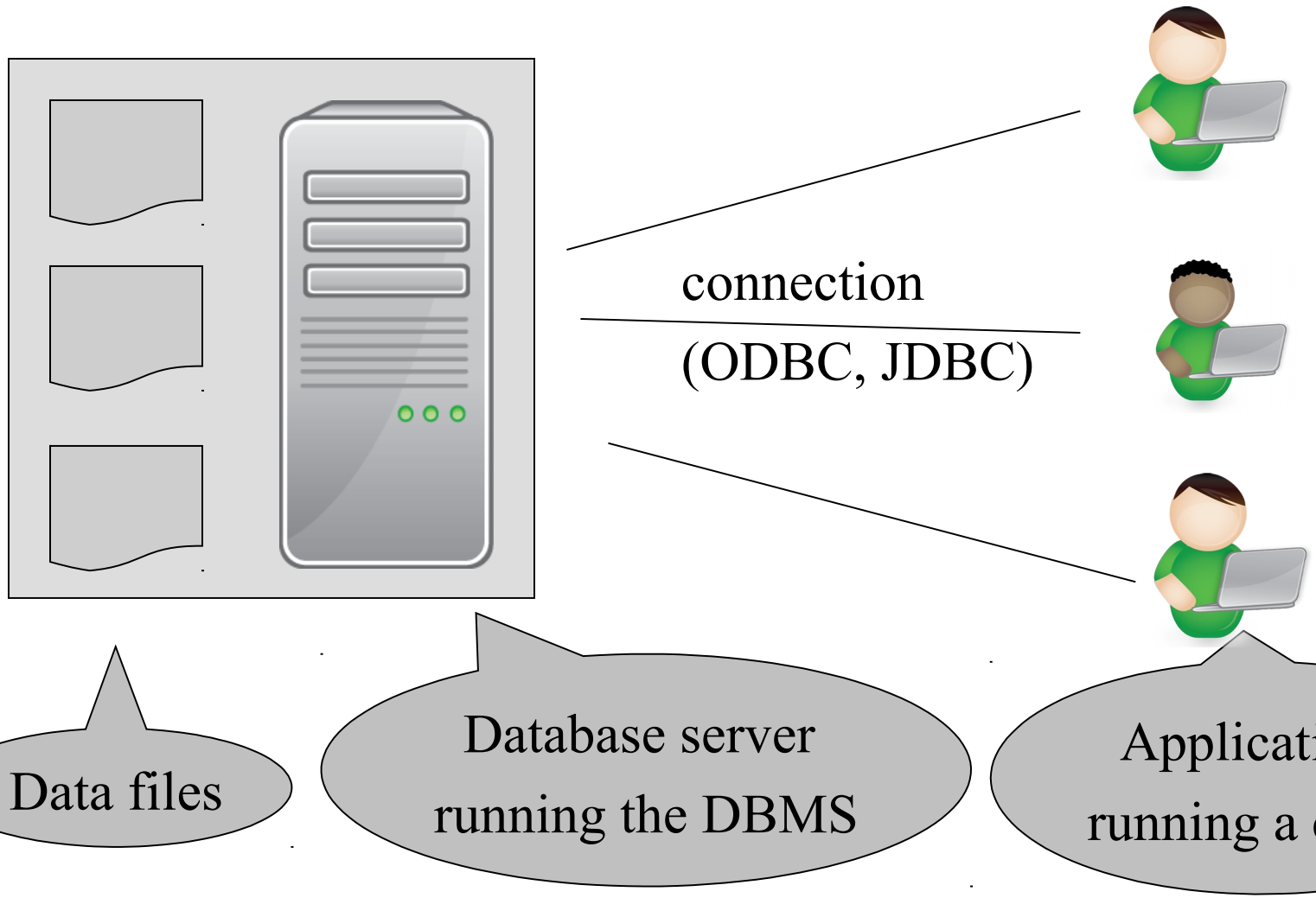
- *A complicated (and often expensive) piece of software typically running on a large (remote) server written by someone else that allows us to manage efficiently a large database and allows it to persist over long periods of time.*

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"



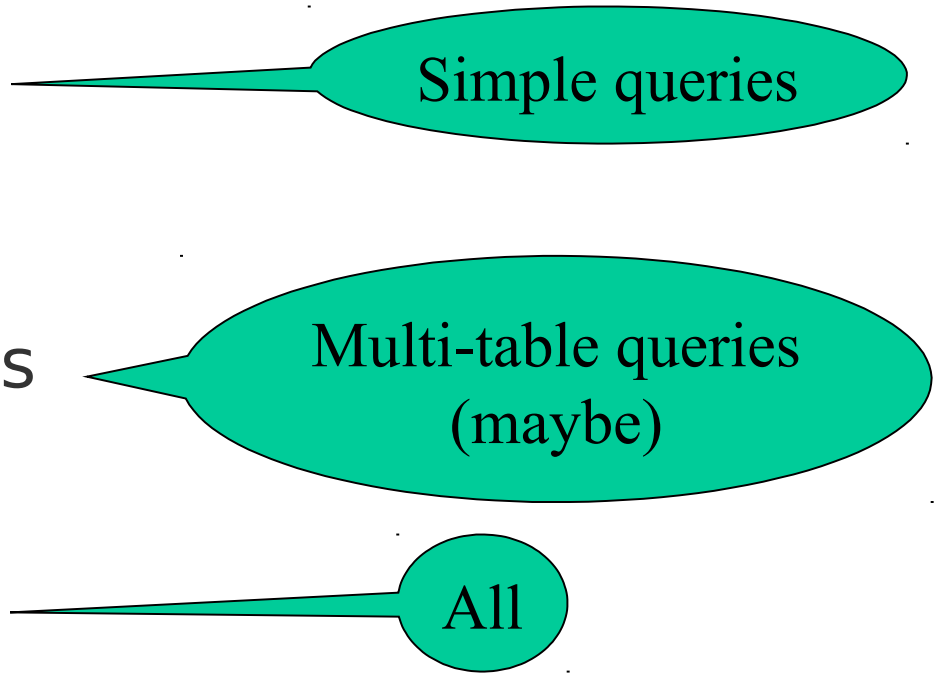
Operations: Query/Update

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)
- Spreadsheets
- DBMS

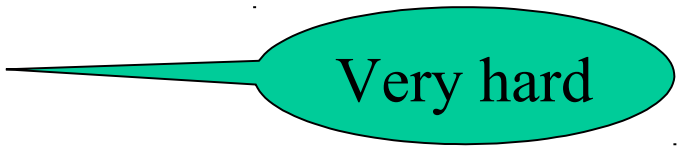


Updates: generally OK

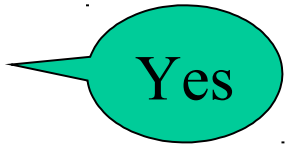
Change the Structure of a DB

Add *Address* to each Actor

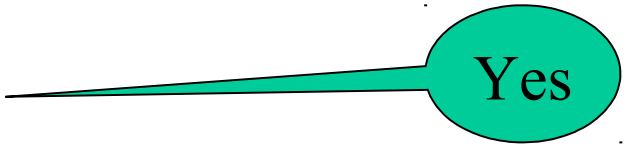
- Files (e.g., CSV)



- Spreadsheets



- DBMS



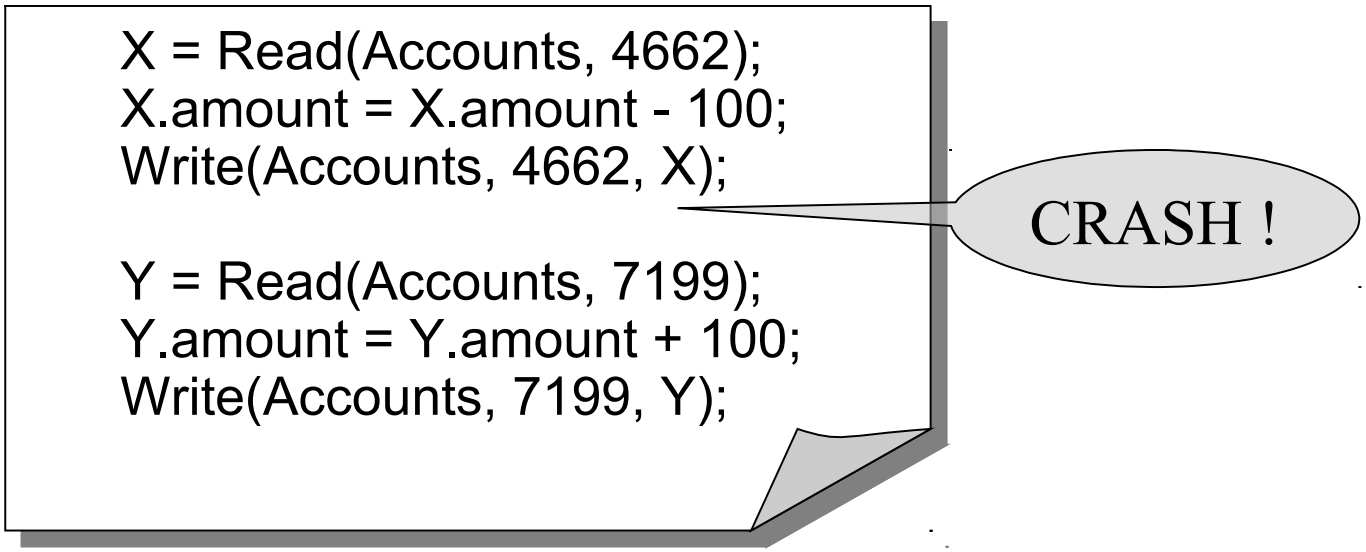
Issue: Concurrent Access

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:



What is the problem ?

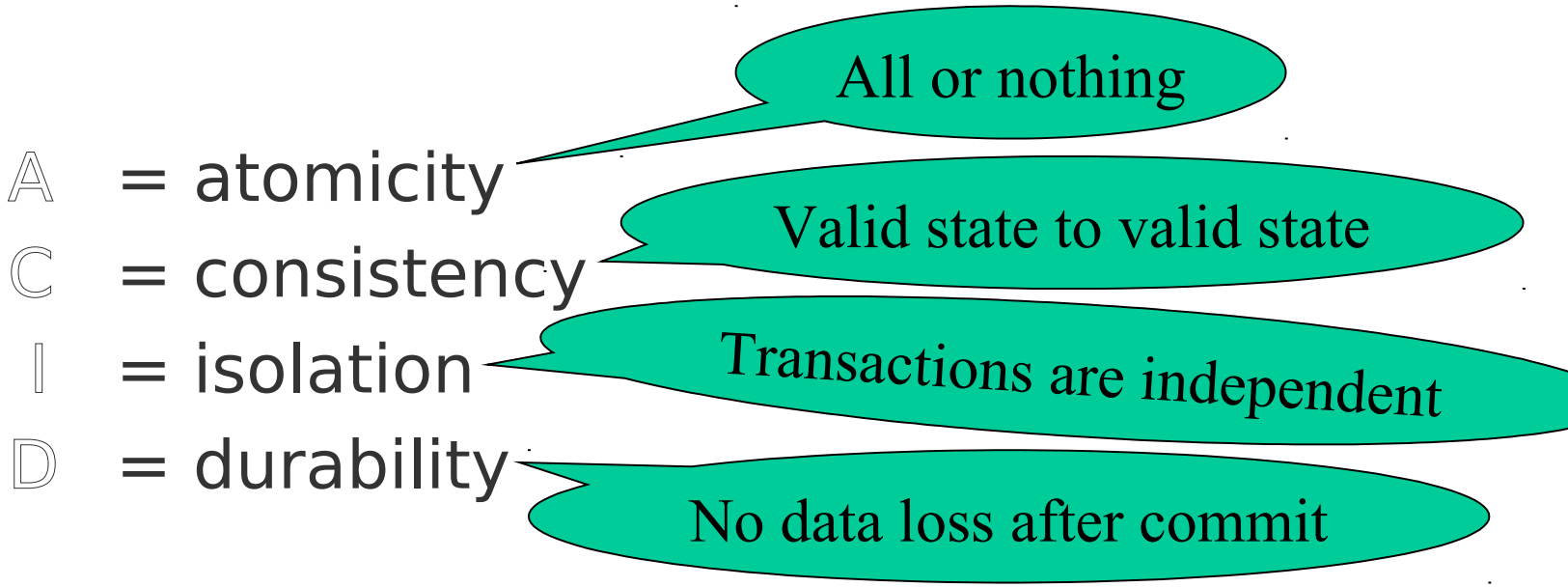
Concurrency & Recovery: Transactions

- 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
```

Transactions

Transactions have the **ACID** properties:



Transactions also allow rollbacks (undo).

Relational Data Base
= Collection of Tables

Actors:

id	fName	lName
15901	Harrison	Ford
. . .		

Movie_Actors:

id	mid
15901	130128
. . .	

Movies:

mid	Title	Year
130128	Star Wars	1977
. . .		

Still implemented as files, but behind the scenes can be quite complex.

Create/Store Large Datasets

Use SQL to create and populate tables:

```
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’

```
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...

Change the Structure of a Table

Add *Address* to each Actor

```
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