Carnegie Mellon Univ.
Dept. of Computer Science
15-415/615 - DB Applications

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Lecture#1: Introduction

Today's Agenda

- Course Overview & Logistics
- Introduction of Databases

15-615 Wait List

- We are capped at 90 students.
- We do **not** follow CMU S3's position list.
- You are **not** allowed to swap with somebody already enrolled in the course.

Course Objective

- Students will learn the fundamentals of database management systems.
  - When to use them
  - How to model data with them
  - How to store and retrieve information
  - How to search quickly for information
  - System internals & key algorithms

Course Logistics

- **Course Policies + Schedule:**
  - Refer to course web page.
- **Academic Honesty:**
  - Refer to CMU policy page.
  - If you're not sure, ask the professors.
  - Don't be stupid.

Course Rubric

- Homework Assignments
- Midterm Exam
- Final Exam

Homework Assignments

- All assignments are due at the beginning of the lecture (3:00pm), on the due date.
- All assignments are to be done individually.
- Late policy: Four "Slip" Days
- **HW3 & HW7 require more programming than the other assignments.**

Exams

- **Midterm: Wednesday October 19th**
  - In-class (this room)
  - Materials up to October 12th & HW4 (inclusive)
- **Final: TBA**
  - Comprehensive

Grading

- **Assignments:** 30%
  - See course web page for HW weights.
- **Midterm:** 30%
- **Final**: 40%
- *No extra credit is offered.*

Special Accommodations

- Please contact the professors if you need special accommodations for the homework or exams **before** the due dates.
- Refer to CMU Accommodations Page

Office Hours

- **Christos (GHC 8019)**
  - Tuesdays @ 2pm-3pm
- **Andy (GHC 9019)**
  - Mondays @ 12pm-1pm
- Also available by appointment.
- See course website for TA hours.

Course Message Board

- On-line discussion through Blackboard:
  - http://cmudb.io/15415-f16-blackboard
- If you have a technical question about homework, please use Blackboard.
  - Don't email profs or TAs directly.
- All non-project questions should be sent to the professors.

Lecture Questions

- Ask questions during the lecture.
- If you are unsure about something, then somebody else might have the same question.
- Don't run up to talk to the professors immediately after the lecture.

Course Topics

- Introduction to Databases
- Data Models
- Query Language (SQL)
- Database Design
- Query Optimization & Indexing
- Transaction Management
- Advanced Topics

Spring 2017

- **15-721 – Database Systems**
  - High-performance in-memory system internals
  - Programming intensive
- **15-826 – Multimedia DBs & Data Mining**
  - Graph mining, time-series analysis, databases for machine learning.
  - Non-relational data

Database Talks (Optional)

- The CMU DB group hosts research/industry talks throughout the semester.
- More information:
  - http://db.cs.cmu.edu/events/

Research Positions (Optional)

- We are looking for students to help build CMU's new flagship DBMS (Peloton)
  - Database Internals (C++11)
  - Autonomous Operation (TensorFlow)
- **Come to the project info meeting:**
  - Friday Sept 9th @ 12:30 (GHC 9115)
  - http://cmudb.io/fall2016-positions

What is a Database?

Database Example

- Or why should you take this course?
- Let's build a simple application…

Database Example

- Create a database to keep track of the music that is available in our application.

Flat File Strawman

- Store the data in comma-separated value (CSV) files.
  - Use a separate file per entity.
  - The application has to parse the files each time they want to read/update records.

```
for line in file:
   record = parse(line)
   if searchKey in record:
     // Do something!
```


Database Example

- Create a database to keep track of the music that is available in our application.

Flat Files: Data Integrity

- How do we ensure that the artist is the same for each album entry?
- What if somebody overwrites the album year with an invalid string?
- What if there are multiple artists on an album?

Flat Files: Implementation

- How do you find a particular record?
- What if we now want to create a new application that uses the same database?
- What if two threads try to write to the same file at the same time?

Flat Files: Security

- What if only want some people to see some of the records data in a file?
- What about all of the records but only some of their attributes?

Flat Files: Durability

- What if the machine crashes while we're updating a record?
- What if we want to replicate the database on multiple machines for high availability?

Database ≠ Database Management System

Database Management System

- A **DBMS** is software that allows applications to store and analyze information in a database.
- A general-purpose DBMS is designed to allow the definition, creation, querying, update, and administration of databases.

DBMS Types: Data Models

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- Relational — **Traditional / NewSQL**
- Key/Value
- Graph
- Document
- Column-family — **NoSQL**
- Array/Matrix
- *Obsolete: Hierarchical, Network*

DBMS Types: Target Workload

- **On-line Transaction Processing (OLTP)**
  - Fast operations that only read/update a small amount of data each time.
- **On-line Analytical Processing (OLAP)**
  - More complex read-only queries that read a lot of data all at once to compute aggregate data.

Relational Database Example

- Declare the attributes of each table.
  - Name / Value Types / Constraints

```
CREATE TABLE artist (
  name VARCHAR(32) NOT NULL,
  genre VARCHAR(32),
  country CHAR(3),
  PRIMARY KEY (name)
);
```

```
CREATE TABLE album (
  name VARCHAR(64) NOT NULL,
  artist VARCHAR(32) NOT NULL
   ↪REFERENCES artist(name),
  year INT CHECK(year > 0),
    PRIMARY KEY (name)
);
```

```
CREATE TABLE track (
  name VARCHAR(64) NOT NULL,
  album VARCHAR(64) NOT NULL
   ↪REFERENCES artist(name),
  tracknum SMALLINT
    ↪CHECK(tracknum > 0),
  PRIMARY KEY (name, tracknum)
);
```


DBMS: Fundamental Concepts

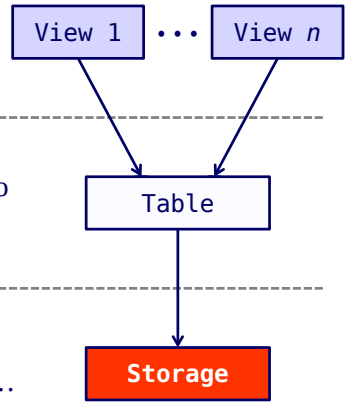
- Three-level Architecture
- Logical Data Independence
- Physical Data Independence

Three-level Architecture

View Level
What information is exposed to users, what are they allowed to see…

Logical Level
What tables are there, what attributes do they have, what constraints should the DBMS enforce…

Physical Level
How data is stored, where it is located, how many bytes, what type of indexes…



Logical Data Independence

- We can modify our table definitions without having change our application's views.
- Example:
  - Add/drop/rename attributes for a table.
  - Rename a table.

Physical Data Independence

- We can change how/where database objects are represented in the physical storage.
- Examples:
  - Use 32-bits instead of 64-bits for integers.
  - Convert an index from a B+Tree to a SkipList.
  - Compress a table when it is stored on disk.
  - Move a table to another disk/machine.

Course Topics

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Next Class

- Application Modeling
  - Entities
  - Relationships
  - Attributes