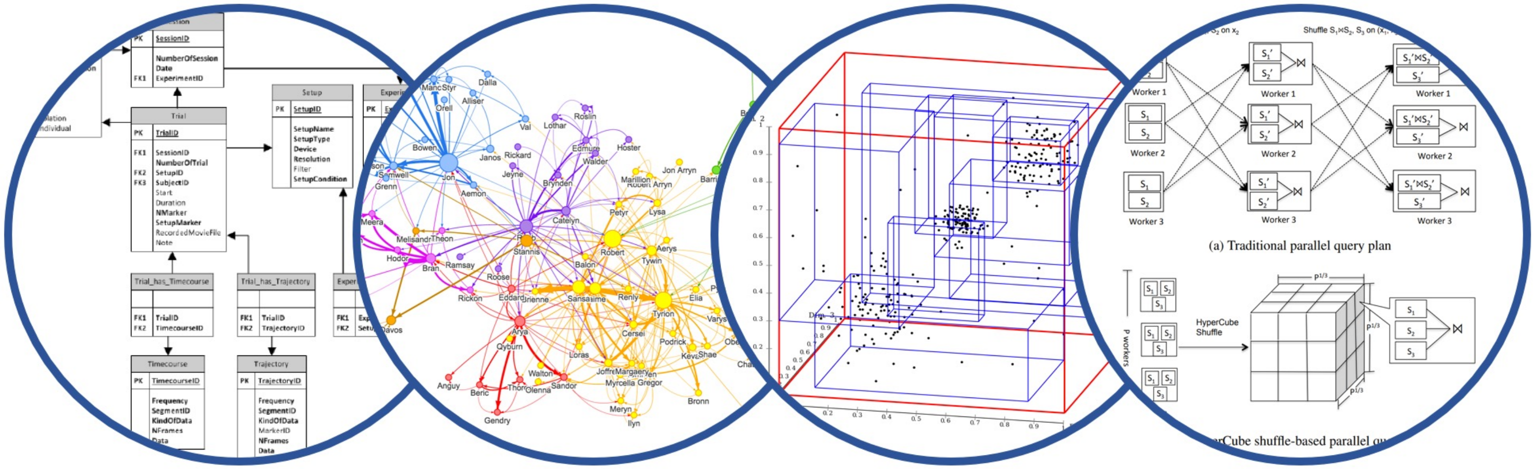


Database System Internals

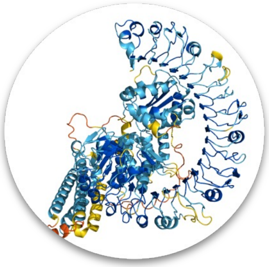
Introduction

Paul G. Allen School of Computer Science and Engineering
University of Washington, Seattle

Why Learn Data Management?

Making Discoveries

Decision support, data mining, large-scale ML. All of these use data systems at their core.



Real Consequences

From vaccine development to financial projection to government services, the world operates on data.

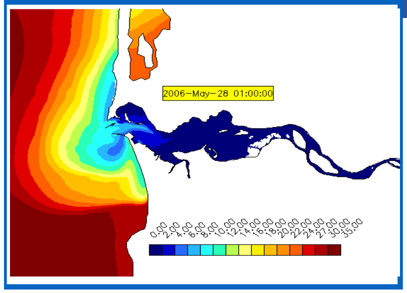
Unprecedented Scale

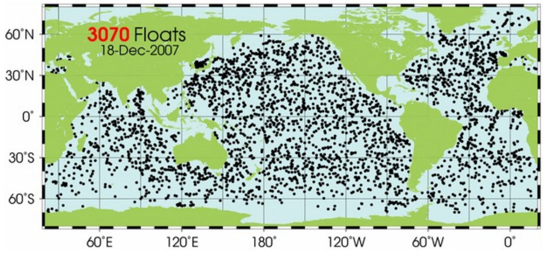
Data collection is happening on anything and everything at an increasing rate.

“The Cereal Aisle”

Hundreds of systems are available to manage data. What are the fundamentals of these systems?

Course Goals





- Need computer scientists to help manage this data
  - Help domain scientists achieve new discoveries
  - Help companies provide better services
  - Help governments become more efficient

- This class: **principles of building data management systems**
  - Learn how classical DBMSs are built
  - Learn key principles and techniques
  - Get hands-on experience building a working DBMS

Course Staff

- Instructors:
  - Ryan Maas

- TAs:
  - Hisham Bhatti
  - Kirsten Graham
  - Kevin Hoang
  - Rohith Leeladharan
  - Alan Wu
  - Alex Zhang
  - Derek Zhu

Email addresses and office hour times and locations will be on the course website and on message board

Course Format

- Lectures MWF @ 10:30am
- Sections: Thursdays
- Homeworks
  - 5 Labs + 6 Written homeworks
- No quizzes or exams!

Course Format

- Add codes and overloading class must wait until week 2 (Allen School policy)

Communication (part 1)

- Web page: http://www.cs.washington.edu/444
  - Lectures/Sections slides will be posted there
  - Homeworks/Labs will be available there
- Mailing list
  - Announcements, group discussions
  - Your @uw.edu address is already subscribed

Communication (part 2)

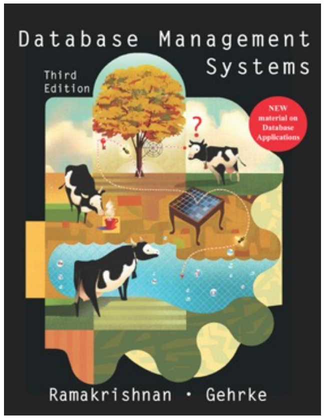
Message Board

- https://edstem.org/us/courses/50739/discussion/
- Ask questions about the course, labs, homeworks
  - Feel free to answer questions too! If you think you know how to answer but are not sure, simply say so
  - Staff will check & answer questions regularly
    - If your question has not been answered in 12 hours, let me know
- Do not post any fragments of your code

Communication (part 3)

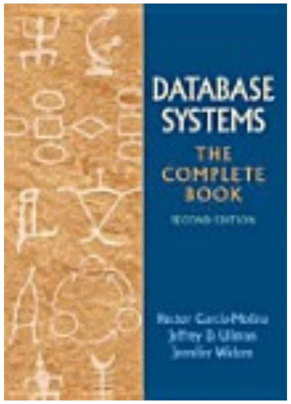
- Send all questions by message board unless
  - You need to discuss a personal matter
  - You want to setup an appointment
  - A question has not been answered on the board

Textbooks


Database Management Systems
Third Edition
NEW material on Database Applications
Ramakrishnan · Gehrke

Recommended textbook (pick one)

- Database Management Systems. **Third Ed**. Ramakrishnan and Gehrke. McGraw-Hill.



- *Database Systems: The Complete Book*, Hector Garcia-Molina, Jeffrey Ullman, and Jennifer Widom. **Second edition**.

See course website for recommended chapters

Other Readings

- See Website

- There is a section on reading assignments for 544M only

Grading CSE 444

- Labs: 50%
  - Includes final project lab

- Final project report 10%

- Six written assignments: 40%

(above subject to +/- 5% adjustment)

Grading CSE 544M

- Same as CSE 444 plus:
  - Another 10% for the 4 paper reviews
  - Then re-normalize to add up to 100%

- Graded separately from CSE 444

Five Labs

Acks: SimpleDB lab series originally developed by Prof. Sam Madden at MIT. We work with them on improving/extending.

- Lab 1: Build a DBMS that can scan a relation on disk
  - **Releasing tonight! Part 1 of this lab is due on Monday.**

- Lab 2: Build a DBMS that can run simple SQL queries and also supports data updates

- Lab 3: Add a lock manager (transactions)
- Lab 4: Add a write-ahead log (transactions)

- Lab 5: Add a query optimizer
- ~~Lab 6: Add support for parallel processing~~ (not this quarter)

About the Labs

Warning: I **will** run cheating-detecting software!
I have solutions from past years too.

Managed on GitLab:

https://gitlab.cs.washington.edu/cse444-24wi/simple-db-[your gitlab id]

Will release tomorrow afternoon

Logistics:

- To be done individually for Lab 1 part 1, you may work with one partner for part 2 and future labs
- Each lab will take a **significant** amount of time
- Labs build on each other

Purpose

- Hands-on experience building a DBMS
- Deepen your understanding significantly
- We will build a *classical* DBMS

Six Homeworks

- Written assignments – upload on Gradescope
- Help review material learned in class
- Prepare you for the labs
    - One homework before each corresponding lab
- Go beyond what we implement in labs
- To be done **INDIVIDUALLY**

Exams

- No quizzes!

- No final!

Late Days

- Total of **6 late-days** for circumstances like illness
- Use in 24-hour chunks on hws or labs
- **At most 2 late-days per assignment**
- No late-days can be applied to the final lab and report due during finals week

- If you are struggling and out of late days, **please reach out** via email or in office hours

Outline (this lecture and next)

- Review of DBMS goals and features
- Review of relational model
- Review of SQL

Review: DBMS

- What is a database? Give examples
  - A collection of related files
  - E.g. payroll, accounting, products

- What is a database management system? Give examples
  - A program written by someone else that manages the database; PostgreSQL, Oracle, …
  - In 444 you are that "someone else", implementing SimpleDB

Review: Data Model

- What is a data model?
  - A mathematical formalism for data

- What is the relational data model?
  - Data is stored in tables (aka relations)
  - Data is queried via relational queries
  - Queries are *set-at-a-time* relational algebra

Review: Transactions

- What is a transaction?
  - A set of instructions that must be executed all or nothing

- What properties do transactions have?
  - ACID
  - Better: Serialization, recovery

Review: Data Independence

Review: Data Independence

The application should not be affected by changes of the physical storage of data

- Indexes
- Physical organization on disk
- Physical plans for accessing the data
- Parallelism: multicore, distributed

Key Data Management Concepts

- Data models: Relational, semi-structured
- Schema vs. Data
- Declarative query languages
    - Say what you want not how to get it
- Data independence
    - Physical: Can change how data is stored on disk without maintenance to applications
- Query compiler and optimizer
- Transactions: isolation and atomicity

Course Content

Focus: building a classical relational DBMS

- Review of the relational model (lecture 1 and 2)
- DBMS architecture and deployments (lecture 3)
- Data storage, indexing, and buffer mgmt (lectures 4-6)
- Query evaluation (lectures 7-8)
- Query optimization (lectures 9-12)
- Transactions (lectures 13-19)
- Parallel query processing (lectures 20-23)
- Replication and distribution (lectures 24-25)
- NoSQL and NewSQL (lectures 26-27)

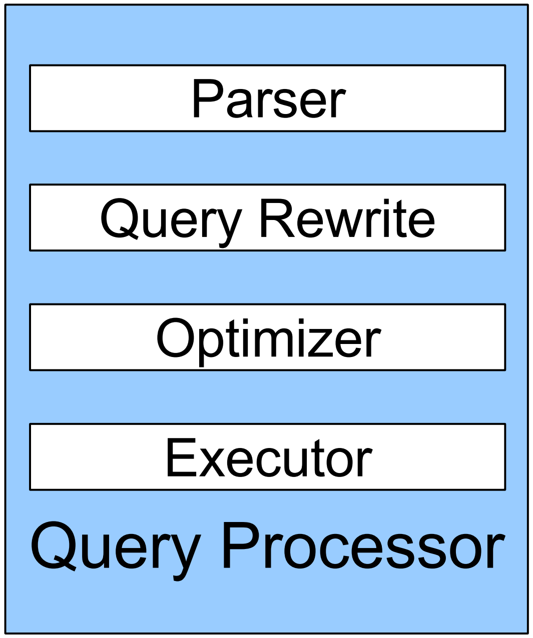
Relational Model...

- The foundation of our traditional database management system

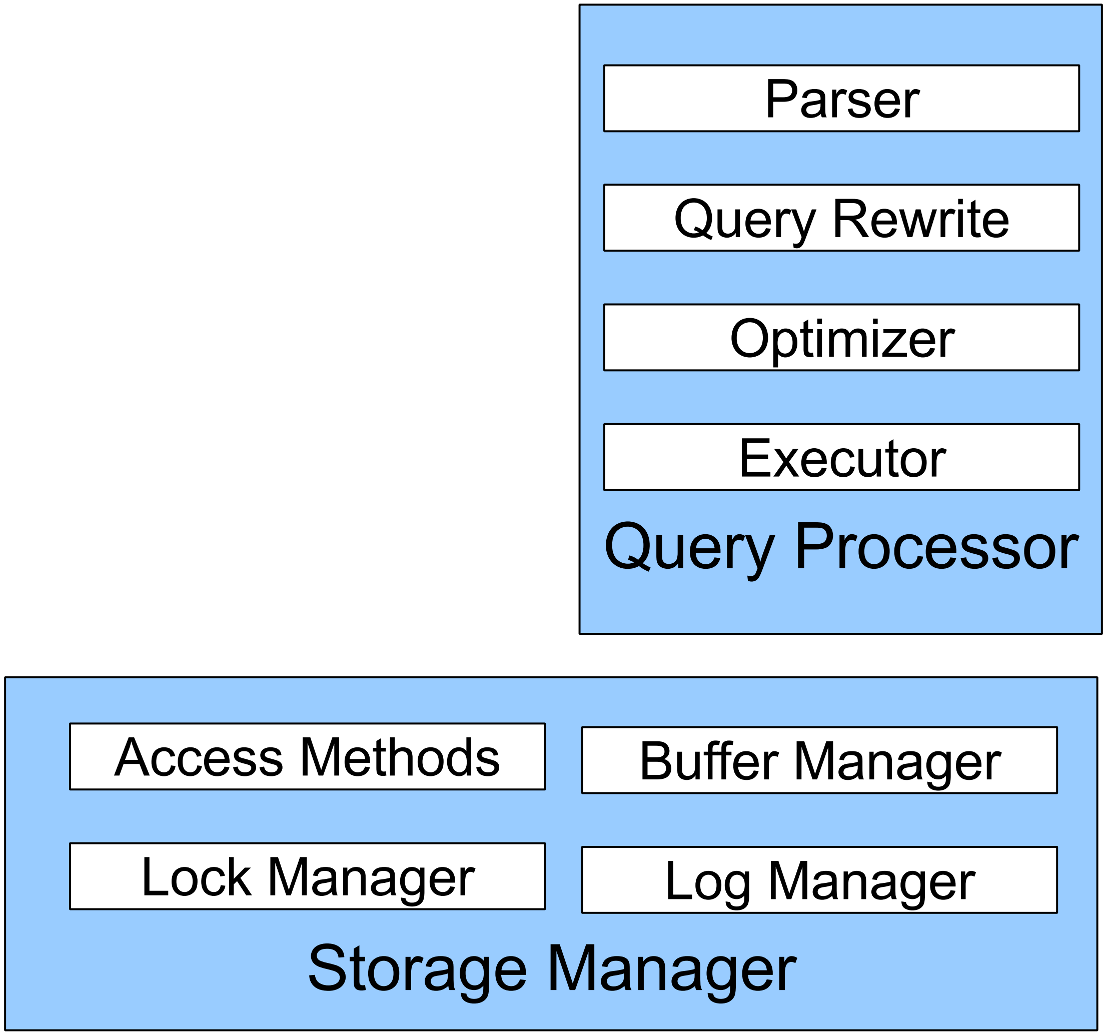
- We'll continue our review of the relational model next lecture …

DBMS Architecture

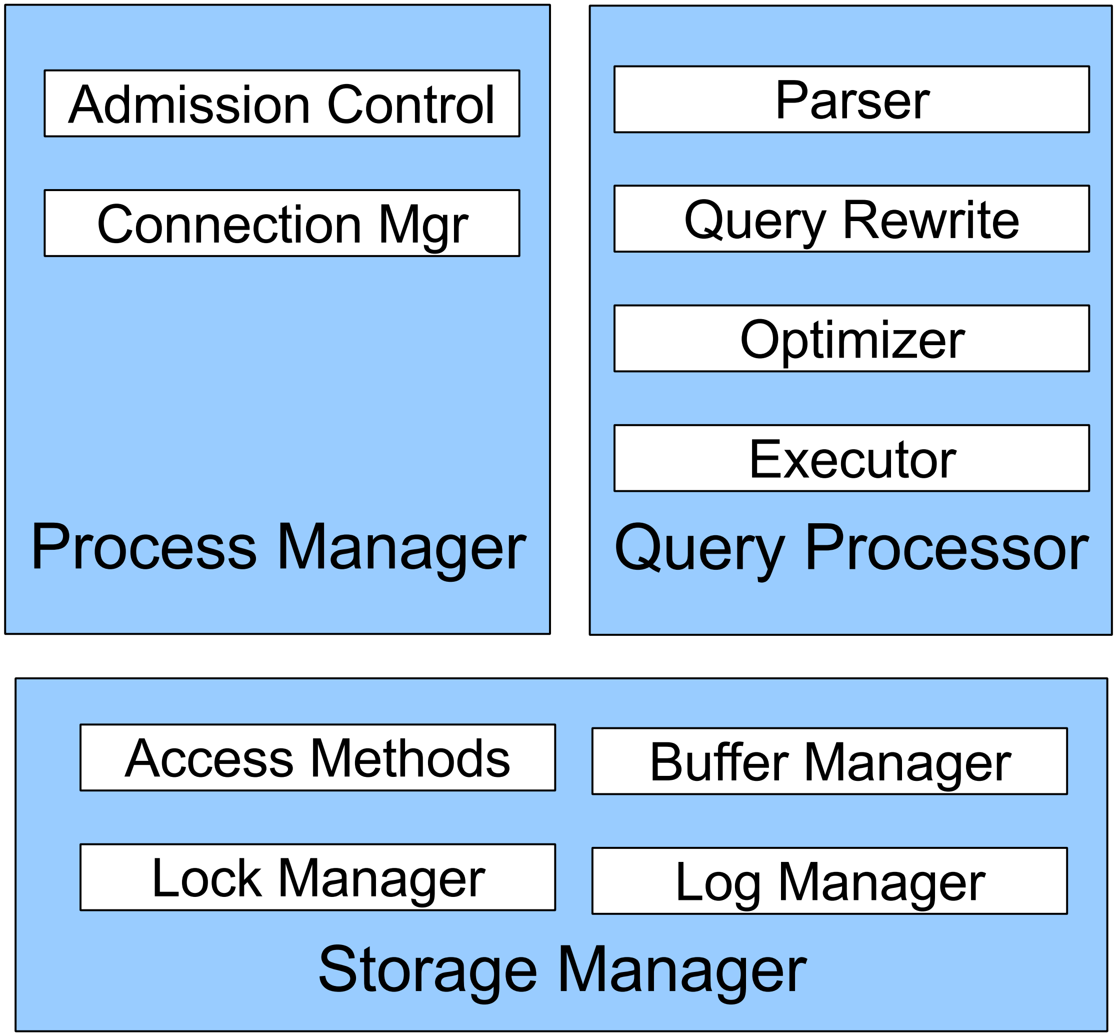
DBMS Architecture



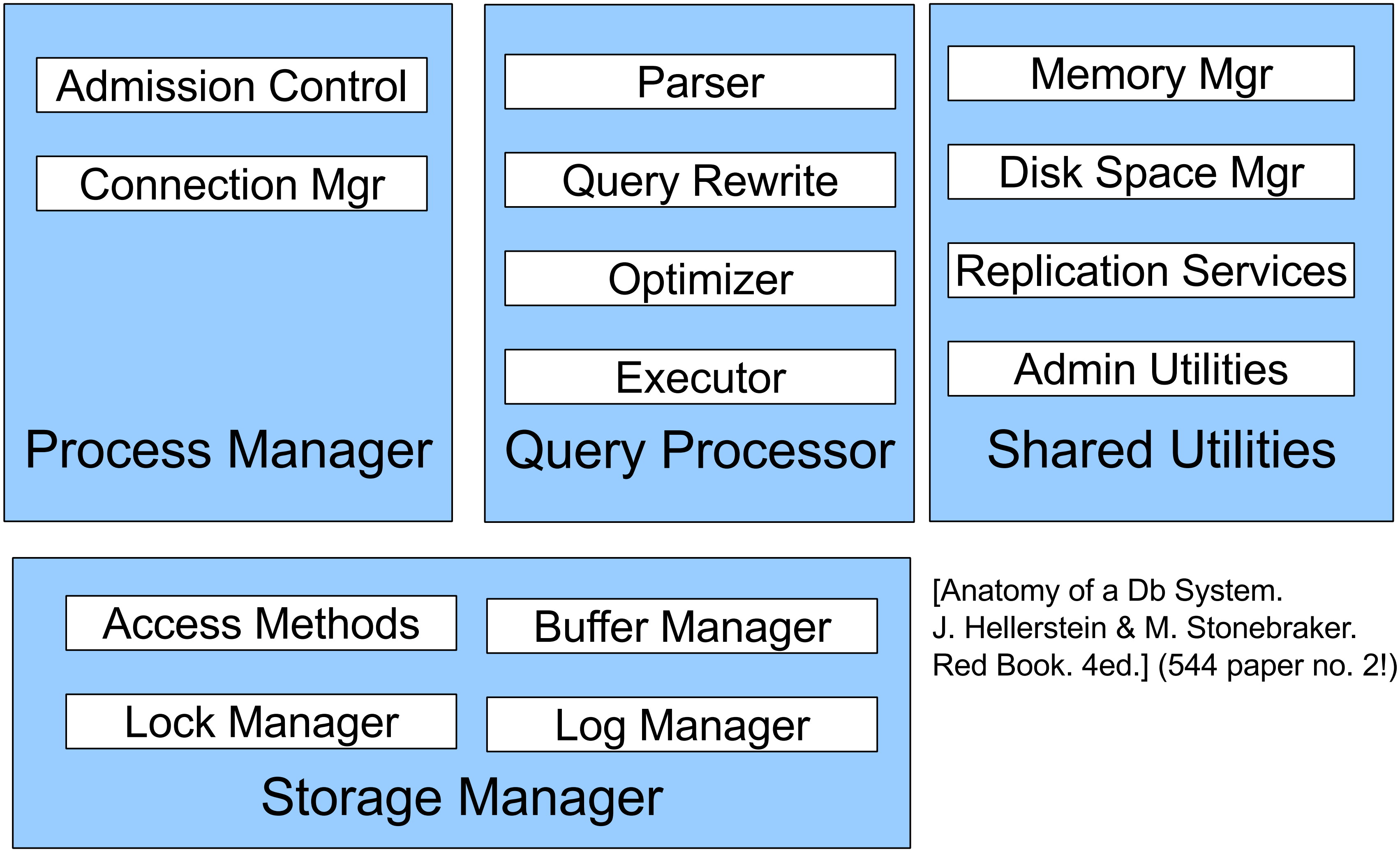
DBMS Architecture



DBMS Architecture



DBMS Architecture



[Anatomy of a Db System.
J. Hellerstein & M. Stonebraker.
Red Book. 4ed.] (544 paper no. 2!)