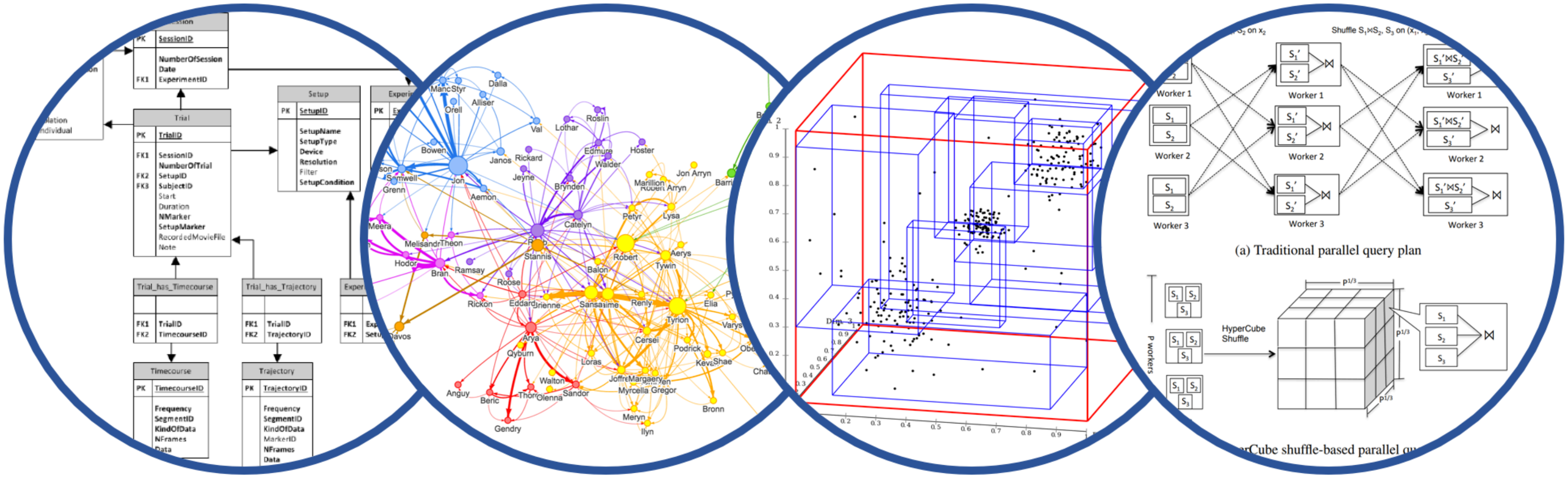


Database System Internals

Introduction

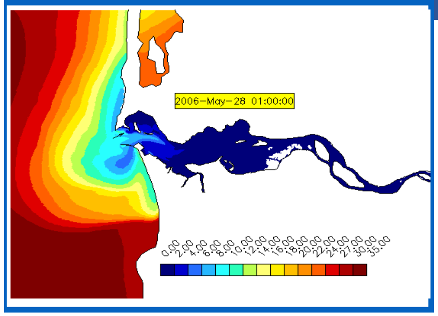
Paul G. Allen School of Computer Science and Engineering
University of Washington, Seattle

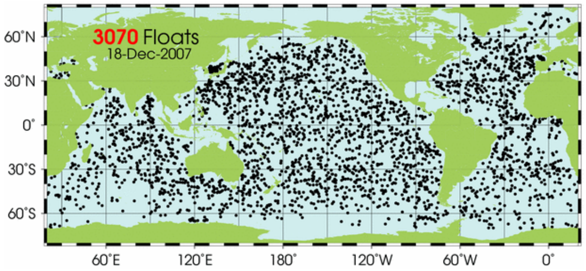
Course Staff

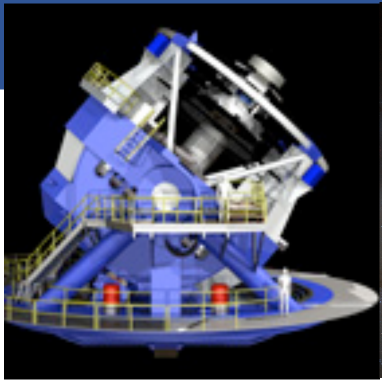
- Instructors:
  - Ryan Maas
- TAs:
  - Pranay Mundra
  - Prati Dhamija
  - Joseph Kosten
  - Kexuan Liu
  - Yiwen Qiu
  - Aaditya Srivathsan

  - Email addresses and office hour times and locations will be on the course website and on message board
    - Every day one or more of us will have office hours

Course Goals







- The world is drowning in data!
- 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 mgmt systems**
  - Learn how classical DBMSs are built
  - Learn key principles and techniques
  - Get hands-on experience building a working DBMS

Course Format

- Lectures MWF @ 12:30pm

- Sections: Thursdays

- Homeworks
  - 5 Labs + 6 Written homeworks

- Quizzes:
  - 2 short quizzes on Gradescope

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)

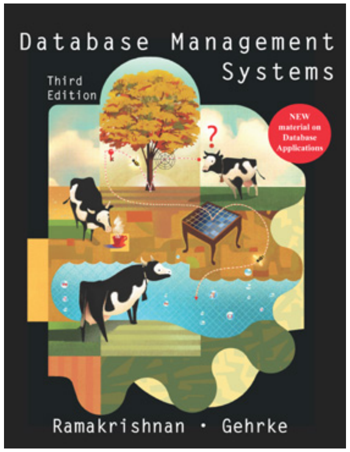
Message Board:

- https://edstem.org/us/courses/4918/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)

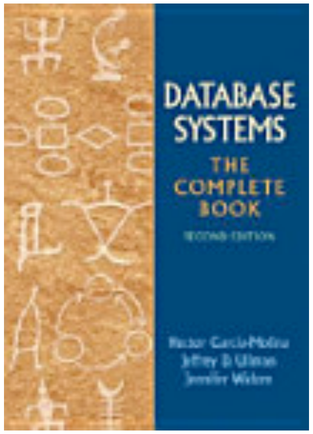
- Do **not** send questions by email unless
  - You need to discuss a personal matter
  - You want to setup an appointment
  - A question has not been answered on the board

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 Jen 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: 40%
  - Includes final project lab

- Final project report 10%

- Six written assignments: 30%

- Two quizzes 20%

(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 later 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/cse444-21sp/simple-db-[your gitlab id]

Will release tomorrow afternoon

Logistics:

- To be done **INDIVIDUALLY!**
- 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

- Homework 1 releases tomorrow. Due next week
- Written assignments – **Print out pdf and fill in answers**
- 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 midterm!
- No final!
- Short take-home quizzes

- Quizzes represent knowledge from labs 1-4
- Tests depth of your knowledge
  - Only one or two open-ended questions
  - Example: “Explain how data is stored in SimpleDB”
  - Grades:
    - 9-10: Strength! Exceptional understanding and explanations
    - 8: You got it!
    - 7 or less: Developing knowledge – some gaps
    - 0: Did not show up or wrote nothing
  - Important: We grade based on the depth of knowledge demonstrated in your answer

Late Days

- Total of **6 late-days**
- 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**

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*

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, XML, graph data (RDF)
- 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: how to build a classical relational DBMS

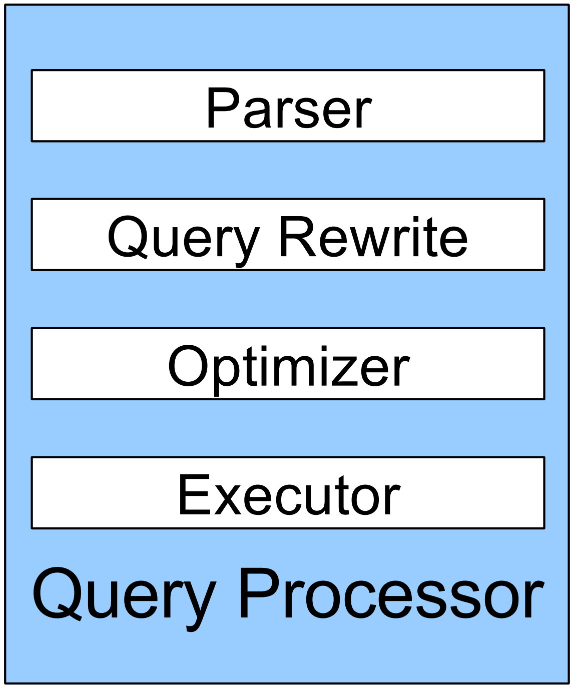
- Review of the relational model (lecture 1 and 2)
- DBMS architecture and deployments (lecture 3)
- Data storage, indexing, and buffer mgmt (lectures 4-6)
- Query evaluation (lectures 7-8)
- Query optimization (lectures 9-12)
- Transactions (lectures 13-19)
- Parallel query processing (lectures 20-23)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

Relational Model...

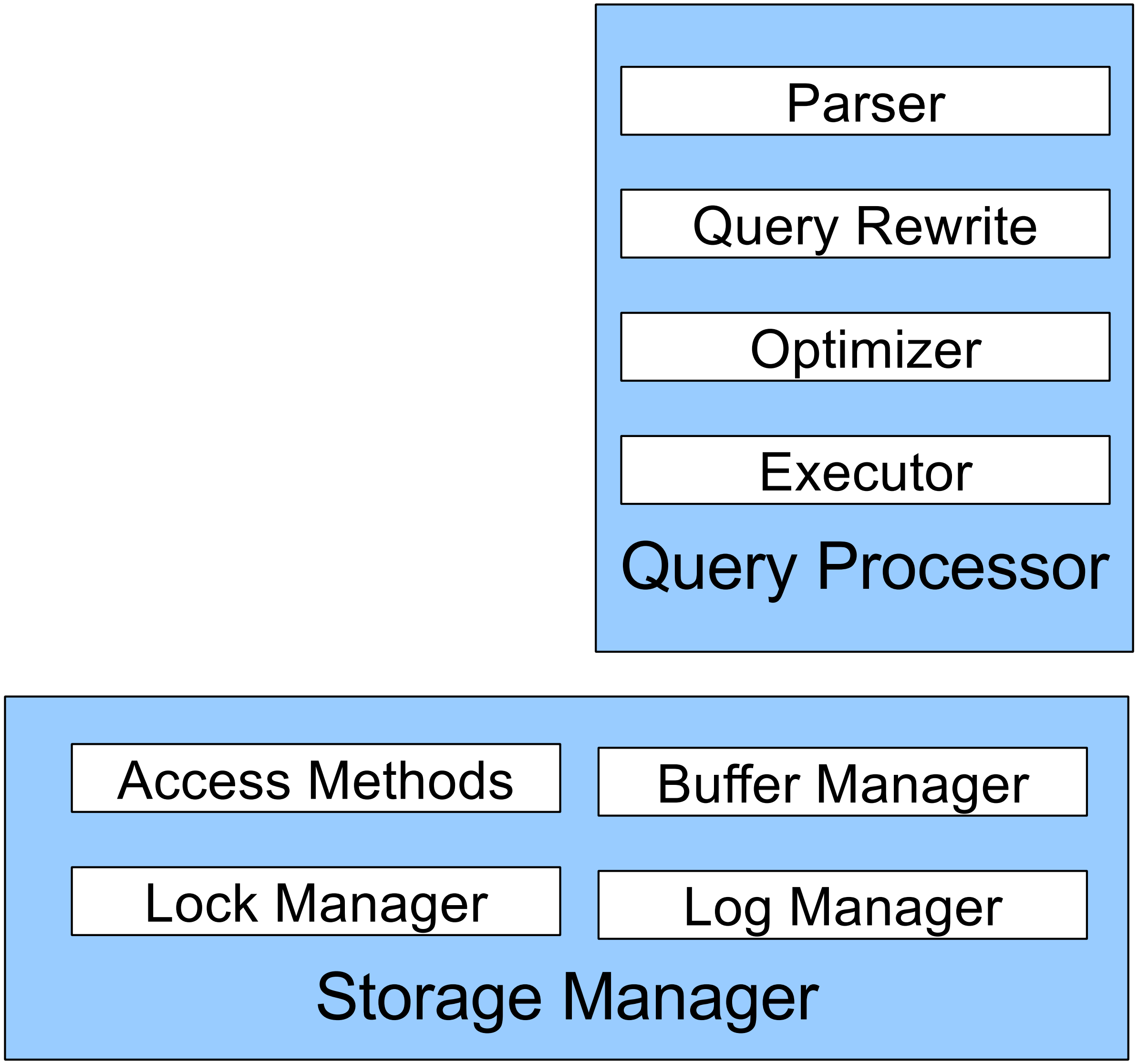
- The foundation of our traditional database management system
- We'll continue our review of the relational model next lecture …

DBMS Architecture

DBMS Architecture



DBMS Architecture



Parser

Query Rewrite

Optimizer

Executor

Query Processor

Access Methods

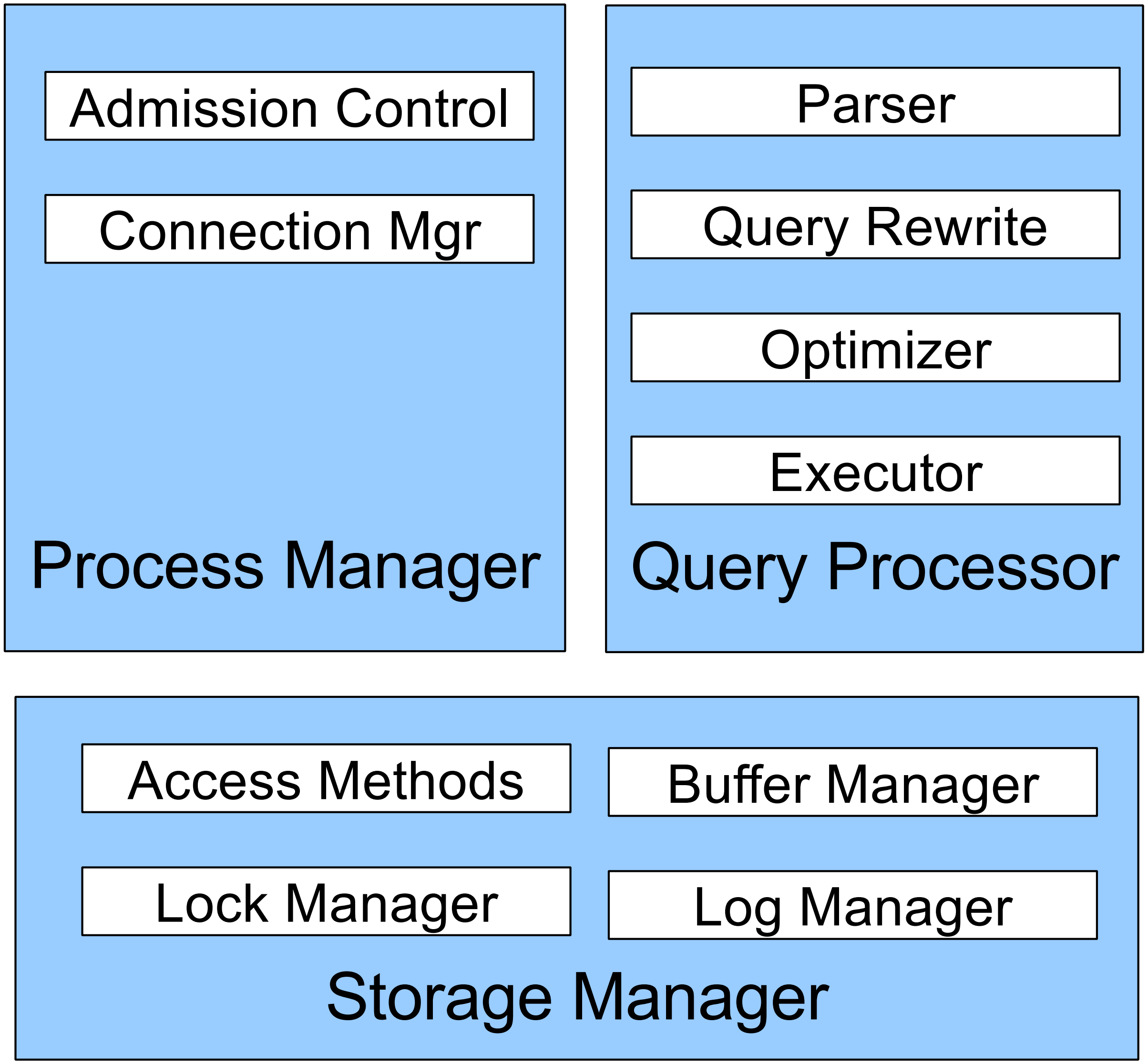
Buffer Manager

Lock Manager

Log Manager

Storage Manager

DBMS Architecture


Admission Control

Connection Mgr

Process Manager

Parser

Query Rewrite

Optimizer

Executor

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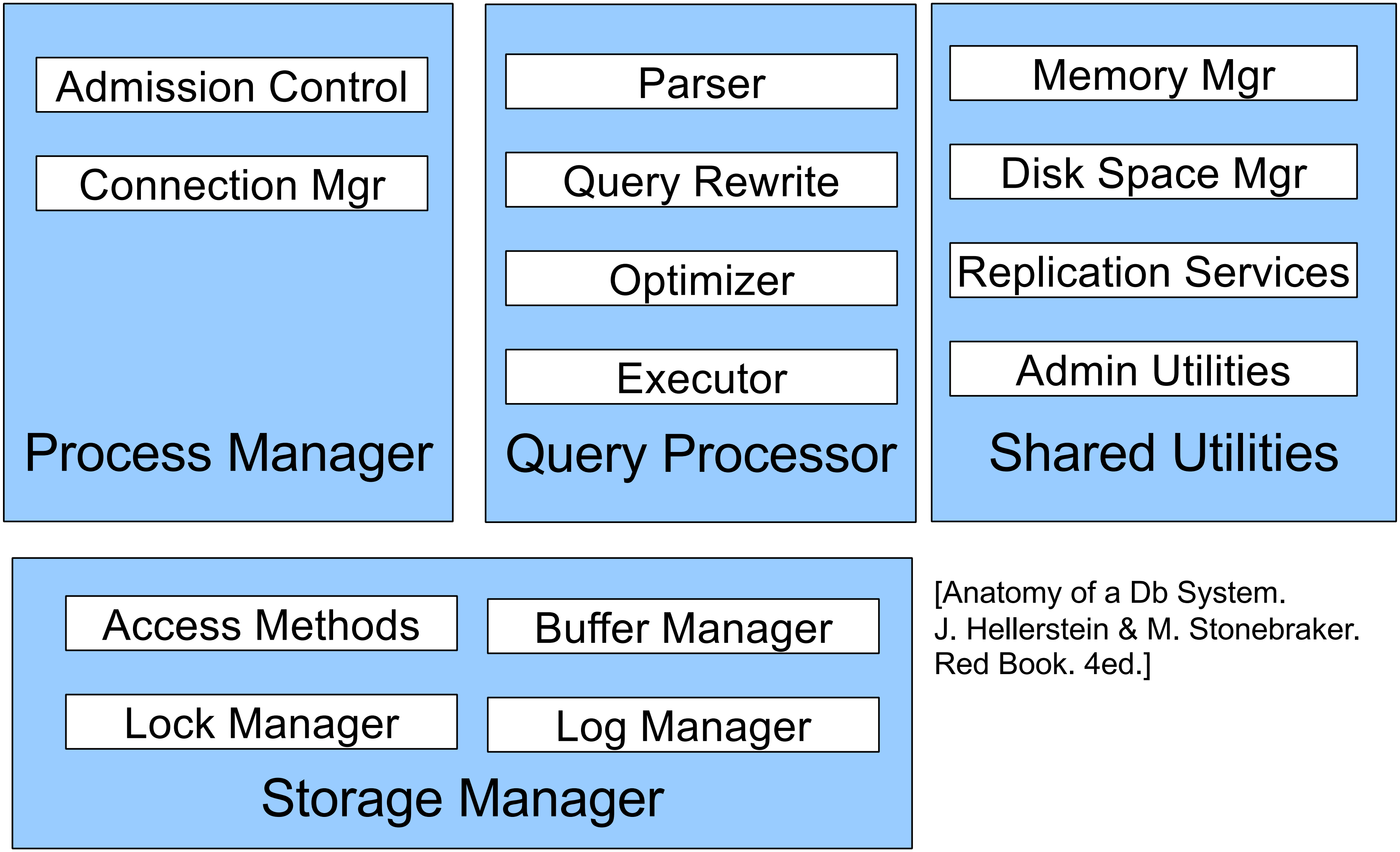
DBMS Architecture



Admission Control

Connection Mgr

Process Manager

Parser

Query Rewrite

Optimizer

Executor

Query Processor

Memory Mgr

Disk Space Mgr

Replication Services

Admin Utilities

Shared Utilities

Access Methods

Buffer Manager

Lock Manager

Log Manager

Storage Manager

[Anatomy of a Db System.
J. Hellerstein & M. Stonebraker.
Red Book. 4ed.]