Database Management Systems

Introduction to Databases

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Let's play a game!!!

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Think why someone was ahead of others ... probably because the data was

- kept at a right place (storage)
- updated last time properly (modification)
- examined with a fast strategy (analysis)

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Think why someone was ahead of others ... probably because the data was

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As a whole, we can say that the data was organized (management) properly by the winner.

Introduction

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Management of data refers to
– *storing* data,
– *modifying* (add, edit, delete) data, and
– *analyzing* (extract data/information) data

Note: A database is a collection of data.

Think about the past

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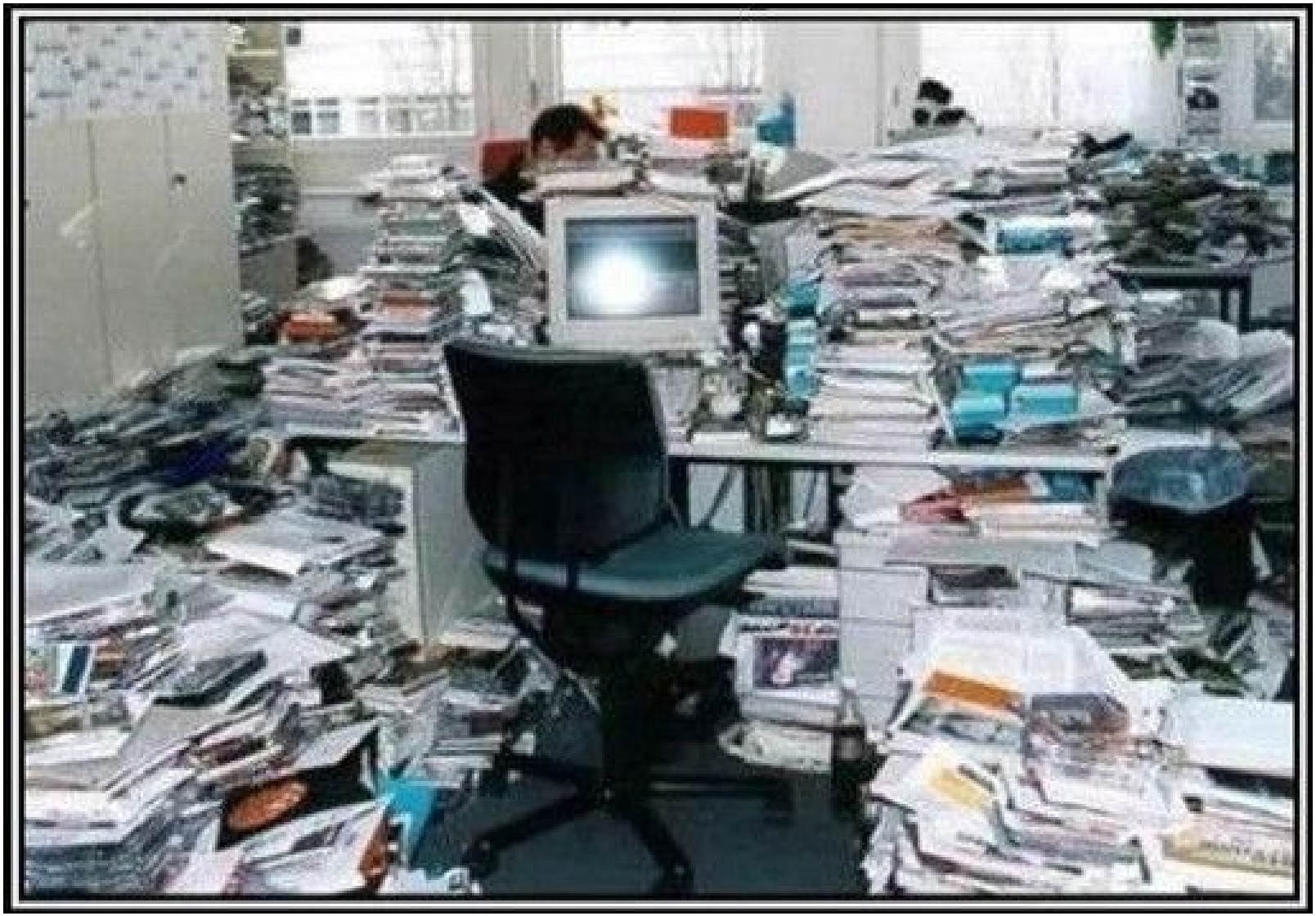
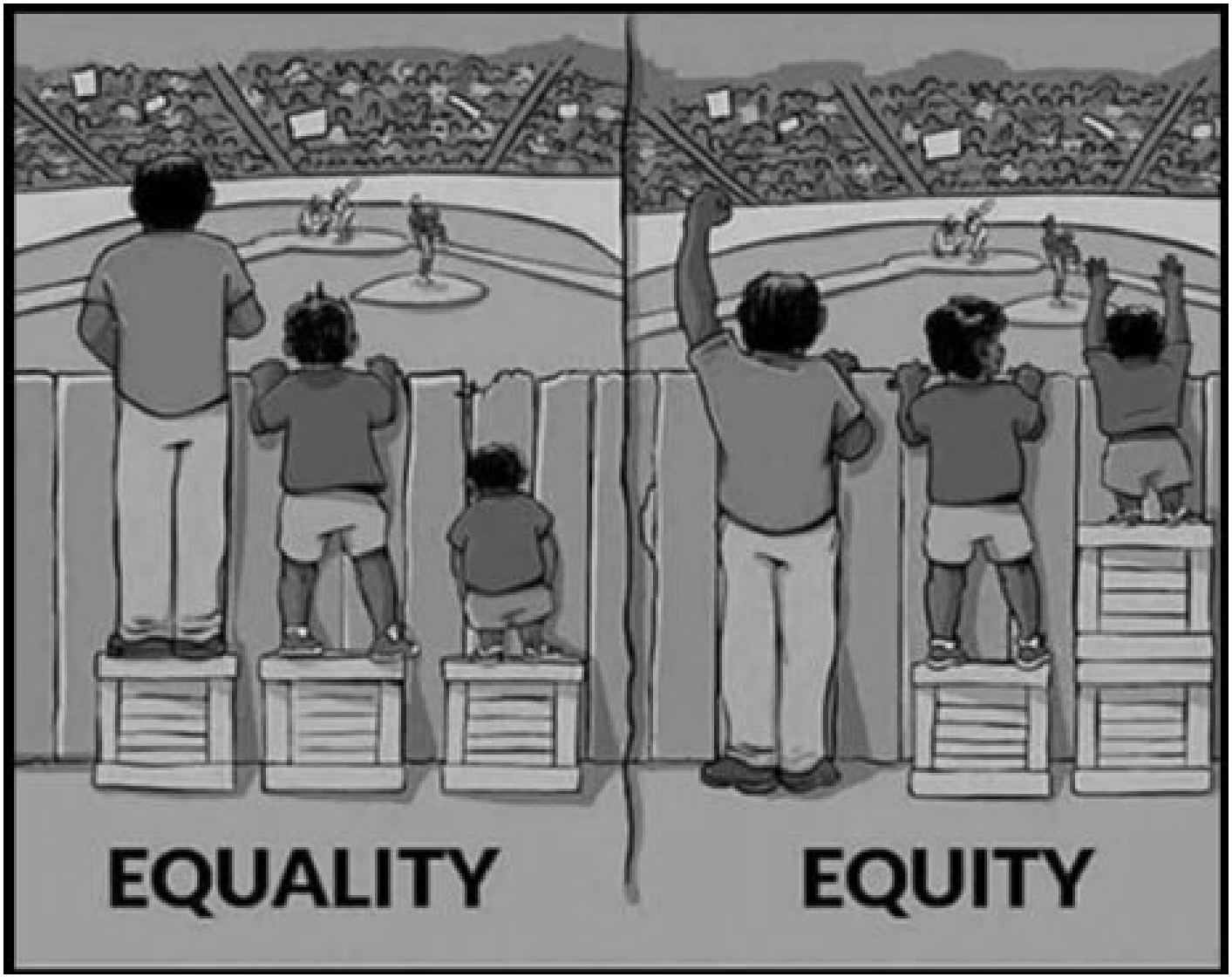
1. Data redundancy and inconsistency – *repeated copies*
2. Difficulty in accessing data – *time complexity*
3. Data isolation – *changes reflected for all*
4. Integrity problems – *accuracy and consistency*
5. Atomicity problems – *everything or nothing*
6. Concurrent-access anomalies – *simultaneous access*
7. Security problems – *privacy*

Data redundancy and inconsistency

Difficulty in accessing data



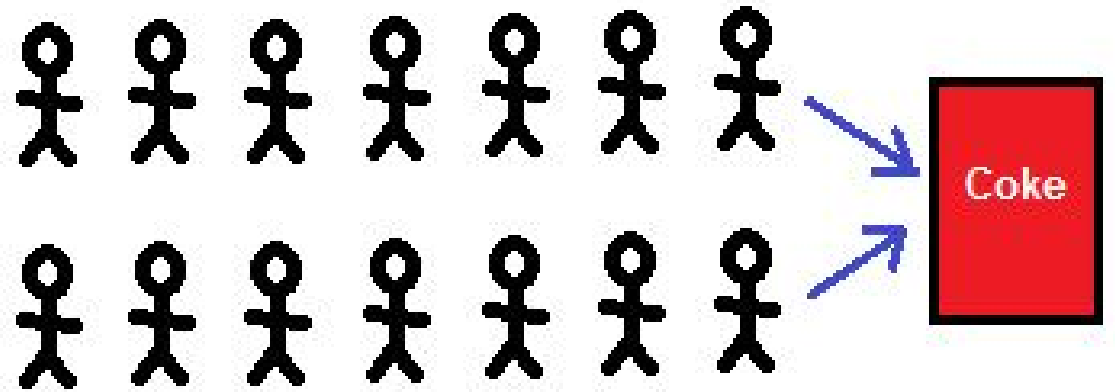
Data isolation



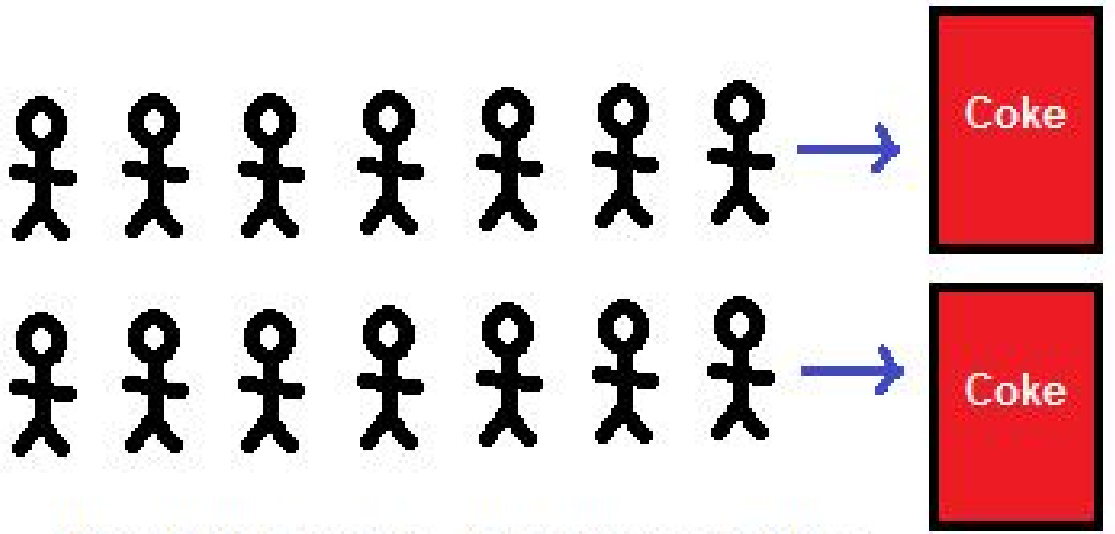
Integrity problems

Atomicity problems

Concurrent-access anomalies



Concurrent: 2 queues, 1 vending machine



Parallel: 2 queues, 2 vending machines

Security problems

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2020s: NewSQL

Data abstraction

External level

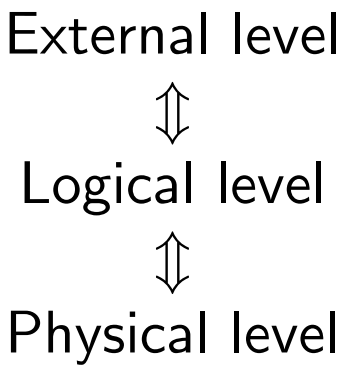
⇕

Logical level

⇕

Physical level

Data abstraction



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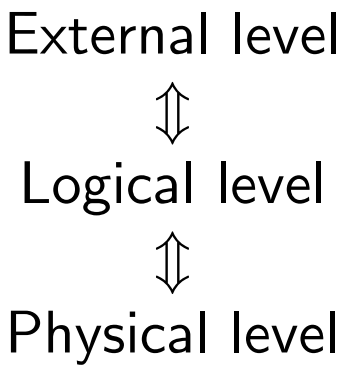
Data abstraction



The collection of information stored in the database at a particular moment is called an *instance* of the database.

The overall design of the database is called the database *schema*.
– *Physical schema* reflects database design at the physical level
– *Logical schema* reflects database design at the logical level

Let us brainstorm!!!

Suppose we wish to create a public repository to keep songs in three different raw formats – the video only, the audio, and the lyrics. The purpose is to allow the users to download these three types of files as and when required. Each of the aforementioned triplet (video, audio, text) is also associated with some metadata like the singer, year, album/movie, lyricist, etc.

Conceptualize a physical design (schema) to store the necessary data files and metadata together.

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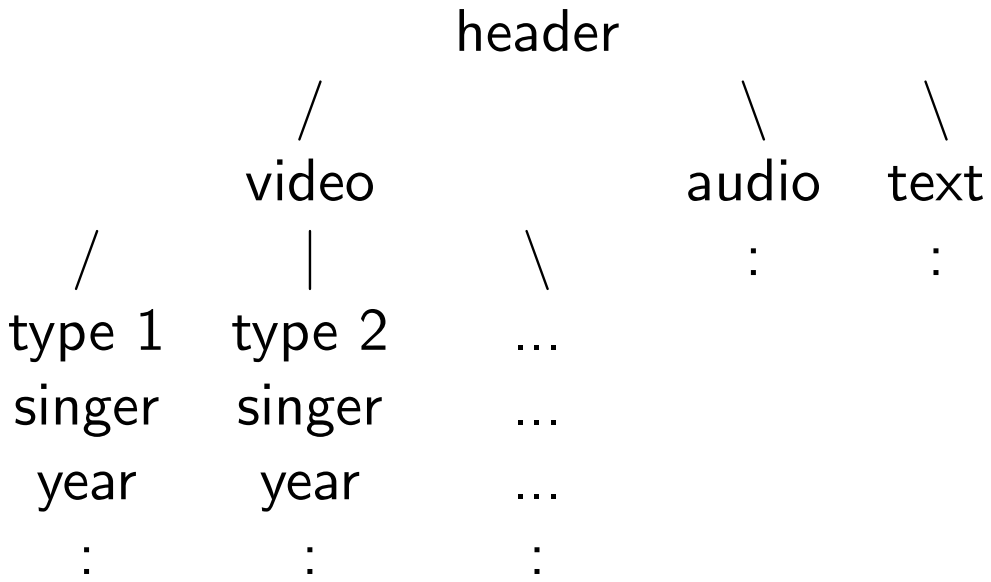
Note: `Polyglot Persistence` is a concept that encourages employing multiple data storage technologies, chosen based on the way data is being used by an application or its component, while storing data.

Idea I

The concept: Use a hierarchical structure to organize the files and their metadata and a hierarchical structure to store the raw files.

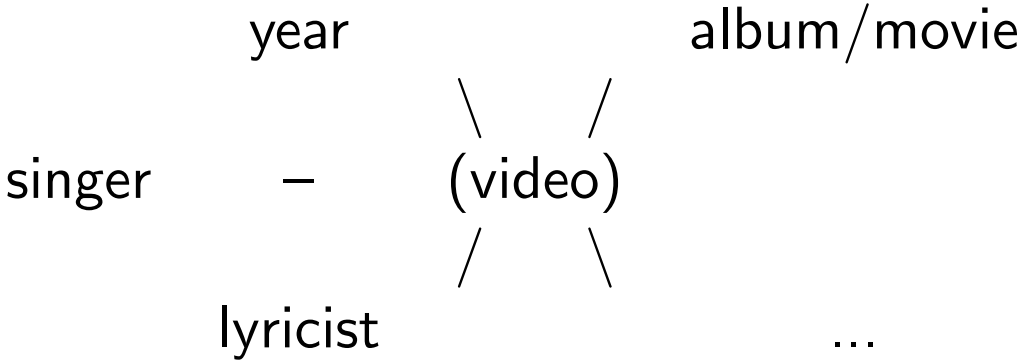


Advantages: Quick access

Disadvantages: Impractical with respect to consistency; One way searching is only possible

Idea II

The concept: Use a networked structure to organize the files and their metadata and store the raw files.



Advantages: Easy access

Disadvantages: One way searching is only possible

Idea III

The concept: Use a table to store the metadata and a hierarchical structure to store the raw files.

Song	singer	year	album/movie	lyricist	...	path
...	...	...	...	...	...	./...

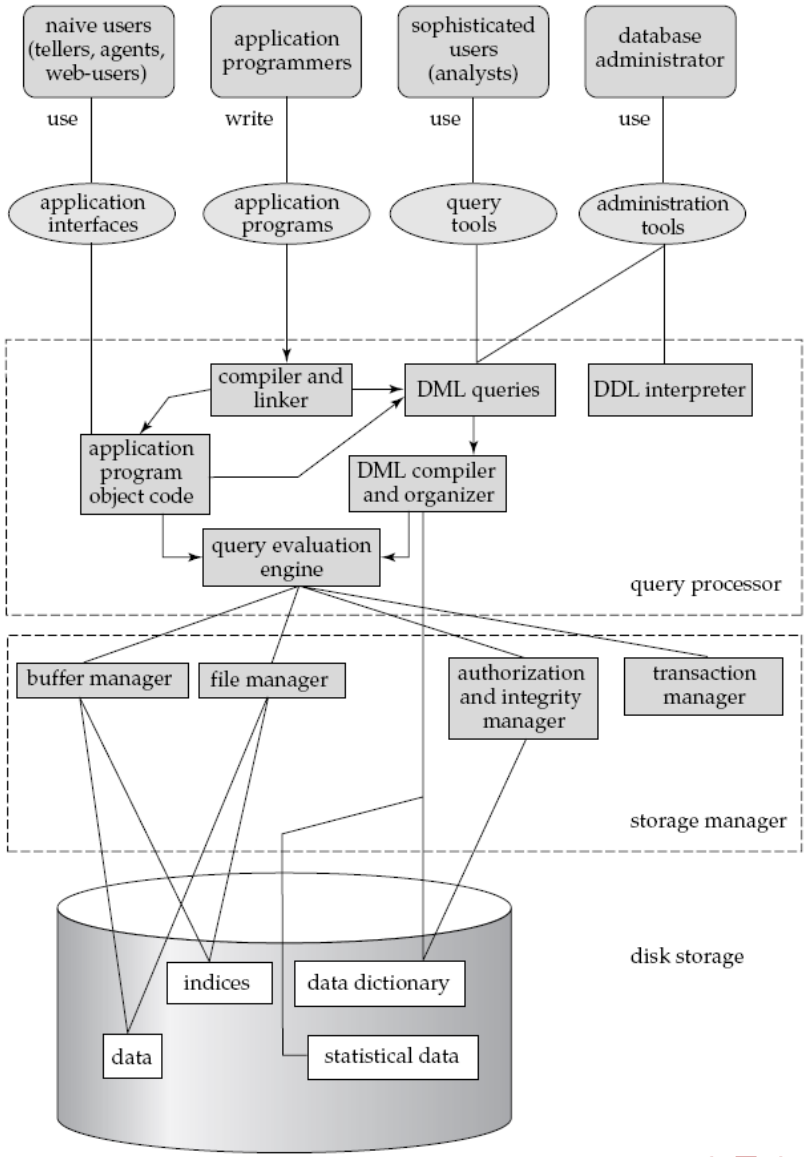
Advantages: Both way searching is possible

Disadvantages: Complex design that blends a relational and hierarchical schema

Languages

- **Data-definition language (DDL):** It specifies the database schema
- **Data-manipulation language (DML):** It expresses database queries and updates for the following tasks.
  1. The retrieval of information stored in the database
  2. The insertion of new information into the database
  3. The deletion of information from the database
  4. The modification of information stored in the database

DBMS System Components



Limitations

1. The developments largely depend on the size of the data
2. Design depends on applications
3. Management complexity
4. Vulnerability to system failure
5. Conversion
6. Increased costs

The concluding remark

The concepts we can acquire as advanced DBMS will soon become conventional

Resources

Books:

1. C. J. Date, An Introduction to Database Systems, Pearson Education, Inc., 8th Edition, 2006.
2. A. Silberschatz, H. F. Korth and S. Sudarshan, Database System Concepts, Tata McGraw-Hill, 6th Edition, 2011.
3. R. Elmasri and S. B. Navathe, Fundamentals of Database Systems, Pearson Education, Inc., 4th Edition, 2004.
4. R. Ramakrishnan and J. Gehrke, Database Management Systems, McGraw-Hil, 3rd Edition, 2007.
5. H. Garcia-Molina, J. D. Ullman and J. Widom, Database Systems: The Complete Book, Pearson Education, Inc., 2nd Edition, 2009.
6. G. Harrison and S. Feuerstein, MySQL stored procedure programming. O'Reilly Media, Inc., 2006.

Resources

Books (contd...):

7. K. Loney, Oracle Database 11g - The Complete Reference, McGraw-Hill, Inc., 2008.
8. I. Bayross, SQL, PL/SQL: The Programming Language of Oracle, BPB Publications, 6th Edition, 2010.
9. G. Fritchey, SQL Server Query Performance Tuning, Apress, 4th Edition, 2011.
10. P. J. Sadalage and M. Fowler, NoSQL distilled: a brief guide to the emerging world of polyglot persistence, Pearson Education, Inc., 1st Edition, 2013.
11. C. J. Date and H. Darwen, Database Explorations: Essays on The Third Manifesto and Related Topics, Trafford Publishing, 2010.

Resources

Journals:

1. ACM Transactions on Database Systems.
2. The VLDB Journal.
3. SIGKDD Explorations.

Conferences:

1. ACM KDD.
2. ACM SIGMOD/PODS.
3. IEEE ICDE.
4. IEEE ICDM.
5. VLDB.

Resources

Similar courses:

1. MIT: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-830-database-systems-fall-2010.
2. Stanford: http://web.stanford.edu/class/cs245.
3. Harvard: http://daslab.seas.harvard.edu/classes/cs165
4. Princeton: http://www.cs.princeton.edu/courses/archive/spr96/cs425.

Advanced courses:

1. Cornell: http://www.cs.cornell.edu/courses/cs632/2001sp.
2. CMU: https://15721.courses.cs.cmu.edu/spring2019.

Home: https://www.isical.ac.in/ malaybhattacharyya/Courses/DBMS/Spring2021
Piazza: https://piazza.com/isical.ac.in/spring2021/cs/home