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Chapter 1: Database Systems

- Organizations use data to keep track of their day-to-day operations. Such data is used to generate information, which in turn is the basis for good decisions.
- Data is likely to be managed most efficiently when it is stored in a database.

Why Database

- Databases evolved from the need to manage **large amounts** of data in an **organized and efficient** manner
- Databases is everywhere ![bg right:60% w:600 Database is everywhere

DIKW Pyramid

- **Data** consists of **raw facts**
- **Information** is about adding context to reveal the **meaning of data**
- **Knowledge** is about **how to use** the information
- **Wisdom** is about **when to take** action ![bg right:50% w:600 DIKW Pyramid

Data versus Information

- Information is the result of processing raw data to reveal the meaning of data
- **Data management** is a discipline that focuses on the proper generation, storage, and retrieval of data ![bg right:60% w:750 Data vs Information

Introducing the Database

- A **database** is a collection of related data.
    - represent a **mini-world** to reflect some aspect of the real world
    - **logically coherent** collection of data with some inherent meaning
    - is designed, built, and populated with data for **a specific purpose**
- A **database management system (DBMS)** is a collection of programs that manages the database **structure** and **controls access** to the data stored in the database. Here, the database refers to a **shared, integrated** computer structure.

- Examples of DBMS: MySQL, Microsoft SQL Server, Oracle Database, MongoDB, Cassandra, Neo4j, ...

Role and Advantages of DBMS

- DBMS presents the end user with a single, integrated view of the data in the database
- DBMS advantages:
    - Improved data sharing
    - Improved data security
    - Better data integration
    - Minimized data inconsistency
    - Improved data access ![bg right:40% w:500 DBMS role

Types of DBMS

- by # of users: single-user, multiple-user
- by location: centralized, distributed, cloud
- by time sensitive: online transaction processing (OLTP), online analytical processing (OLAP)
- by data characteristics: SQL store structured data, NoSQL store unstructured and semi-structured data

Why Should We Learn Database Design

- **Database design** refers to the activities that focus on the design of the database structure that will be used to store and manage end-user data
- Poorly designed databases can lead to slow performance, data integrity issues, security vulnerabilities, and challenges in scaling applications.
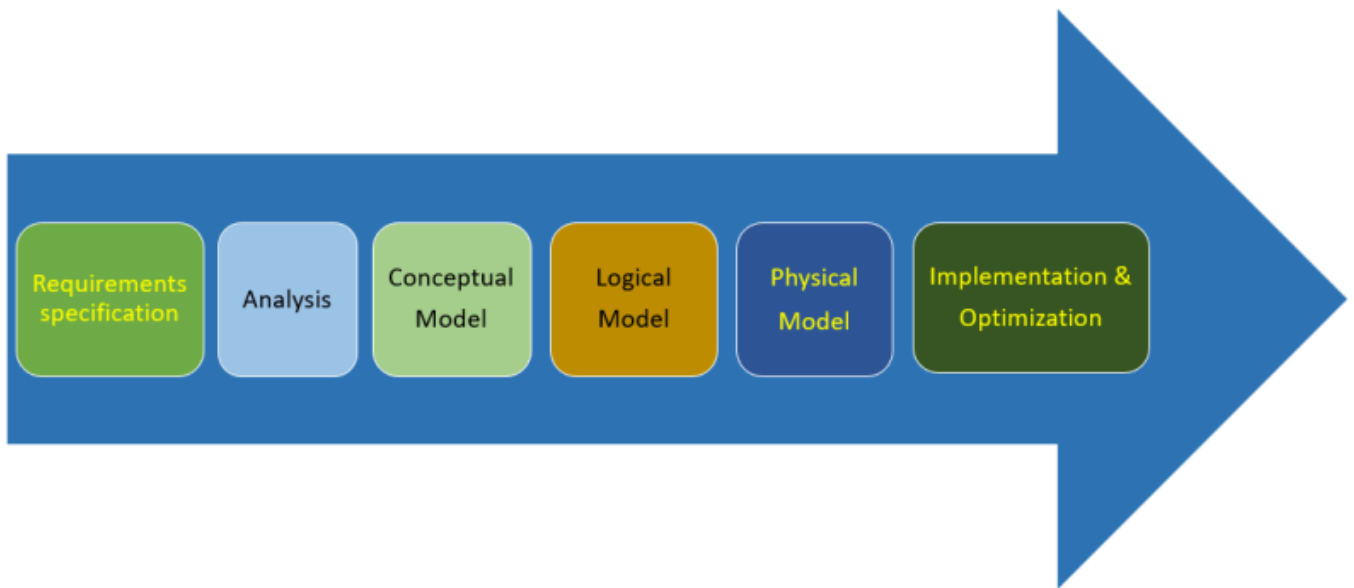
![bg right:50% w:600 poor database design

Database System Design Process

- <span class="brown-text">Requirements & Analysis <span class="small-text">Discover users requirements, analyze what data should

be maintained

- `<span class="brown-text">`Database design
  - `<span class="small-text">`Conceptual model
  - `<span class="small-text">`Choice of a DBMS
  - `<span class="small-text">`Logical model
  - `<span class="small-text">`Physical model
- `<span class="brown-text">`System design: `<span class="small-text">`design system functionality and user interface
- `<span class="brown-text">`Implementation: `<span class="small-text">`realize physical model on running environment and optimize performance

Database Design Process

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bg right:60% w:90%

A Good Database Design Following Database Design Process

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bg right:50% w:600 poor database design

Database System Environment

Collect, store, manage, and use of data within a database environment, including:

- <span class='small-text'>Hardware
- <span class='small-text'>Software
- <span class='small-text'>People
- <span class='small-text'>Procedures
- <span class='small-text'>Data

bg right:55% w:100% database system environment

DBMS Functions

- Data dictionary management to store definitions of data elements and their relationships
- Data storage management
- Security management
- Transaction management and concurrent control
- Backup and recovery management
- Data integrity management
- SQL languages (structured query language)

- Database communication API (application programming interfaces)

Disadvantages of DBMS

- Increased costs
- Management complexity
- Maintaining currency (operation expertise and man power)
- Vendor dependency (vendor lock-in)
- Frequent upgrade/replacement cycles

Database Professional Career

Job Title	Description	Sample Skills Required
Developer	Develop application	Programming, SQL
DBA	Design, manage DBMS	DBMS fundamentals, SQL
Database Designer	Design data models	Domain knowledge, data modeling, DBMS fundamentals, SQL
Data Security Officer	Enforce data security rules	DBMS fundamentals, data security
Data Analyst / Data Scientist	Analyze varied data to generate insights and prediction	Data analysis, statistics, SQL / programming, ML / AI, data visualization

When Not to Use a DBMS

- When costs can not be justified: H/W, S/W, operations
- When a DBMS may be unnecessary: simple applications, limited users

- When a DBMS may be infeasible: embedded systems
- When no DBMS may suffice: real-time requests, complexity of data, special operation

Review Questions

- What is a database
- What is a DBMS
- Which database professional career you are interested in?