

# Database System Concepts

## Chapter 1: Introduction

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Slides (fortemente) baseados nos slides oficiais do livro "Database System Concepts"

# Outline

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# Database Management System (DBMS)



- DBMS contains information about a particular enterprise
  - Collection of interrelated data
  - Set of programs to access the data
  - An environment that is both convenient and efficient to use
- Database Applications:
  - Banking: all transactions
  - Airlines: reservations, schedules
  - Universities: registration, grades
  - Sales: customers, products, purchases
  - Online retailers: order tracking, customized recommendations
  - Manufacturing: production, inventory, orders, supply chain
  - Human resources: employee records, salaries, tax deductions
- Databases touch all aspects of our lives

# Why Database Systems?



- In the early days, database applications were built directly on top of file systems
- Drawbacks of using file systems to store data:
  - Data redundancy and inconsistency
    - Multiple file formats, duplication of information in different files
  - Difficulty in accessing data
    - Need to write a new program to carry out each new task
  - Integrity problems
    - Integrity constraints (e.g. account balance $> 0$) become "buried" in program code rather than being stated explicitly
    - Hard to add new constraints or change existing ones

# Why Database Systems? (cont.)



- Drawbacks of using file systems (cont.)
  - Atomicity of updates
    - Failures may leave database in an inconsistent state with partial updates carried out
    - Example: Transfer of funds from one account to another should either complete or not happen at all
  - Concurrent access by multiple users
    - Concurrent accessed needed for performance
    - Uncontrolled concurrent accesses can lead to inconsistencies
    - Example: Two people reading a balance and updating it at the same time
  - Security problems
    - Hard to provide user access to some, but not all, data
- Database systems offer solutions to all the above problems

# Outline



1 Database Management Systems

2 Database System Concepts
- Data Abstraction Levels
- Data Models
- Database Languages

3 Architecture of a DBMS

4 Database System Design

# Levels of Abstraction

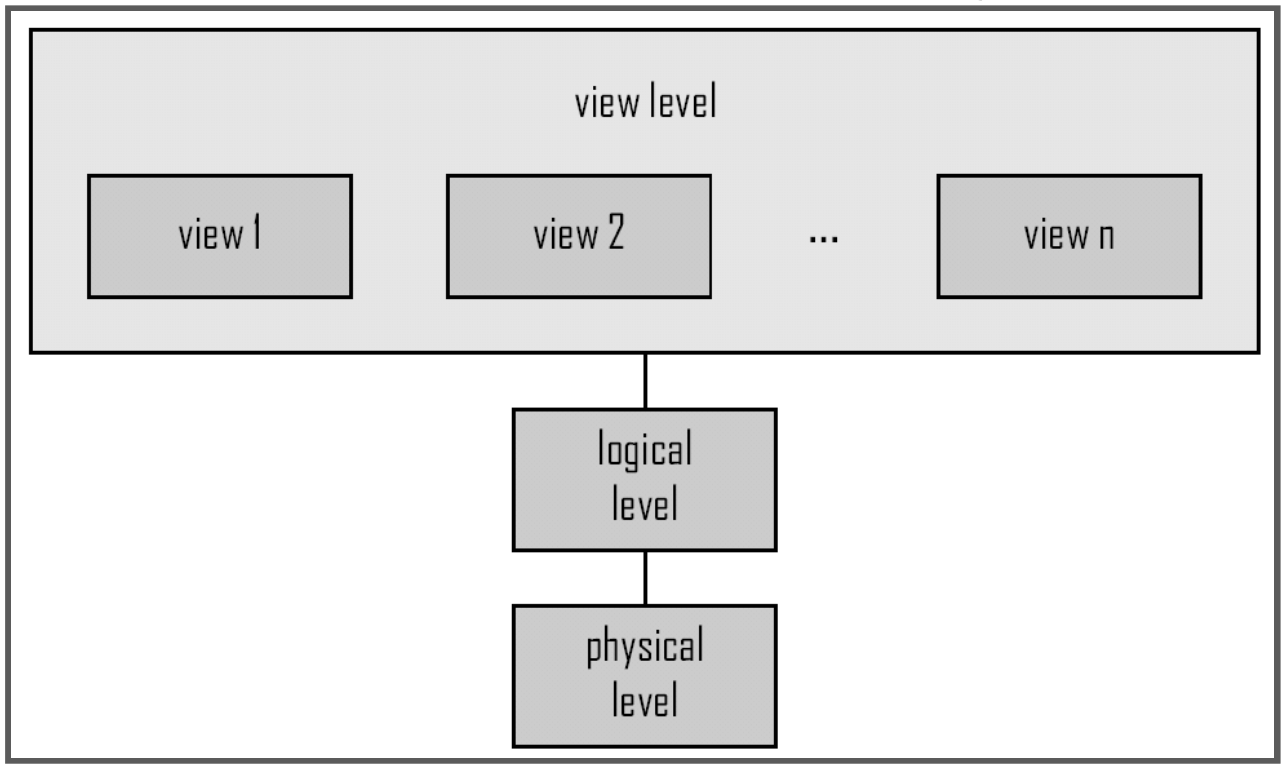


- We can separate the way we view a database in several levels
- Physical level: describes how a record (e.g., customer) is stored.
- Logical level: describes data stored in database, and the relationships among the data.
- View level: application programs hide details of data types. Views can also hide information (such as an employee's salary) for security purposes.

# View of Data



An architecture for a database system



# Data Independence



Physical Data Independence - the ability to modify the physical schema without changing the logical schema

- Applications depend on the logical schema
- In general, the interfaces between the various levels and components should be well defined so that changes in some parts do not seriously influence others.

# Instances and Schemas



- Similar to types and variables in programming languages
- Schema - the logical structure of the database
  - Example: The database consists of information about a set of customers and accounts and the relationship between them)
  - Analogous to type information of a variable in a program
  - Physical schema: database design at the physical level
  - Logical schema: database design at the logical level
- Instance - the actual content of the database at a particular point in time
  - Analogous to the value of a variable

# Data Models



- A collection of tools for describing
  - Data
  - Data relationships
  - Data semantics
  - Data constraints
- Examples:
  - Relational model
  - Entity-Relationship data model (mainly for database design)
  - Semistructured data model (XML)
  - Object-based data models (Object-oriented and Object-relational)

# Relational Model



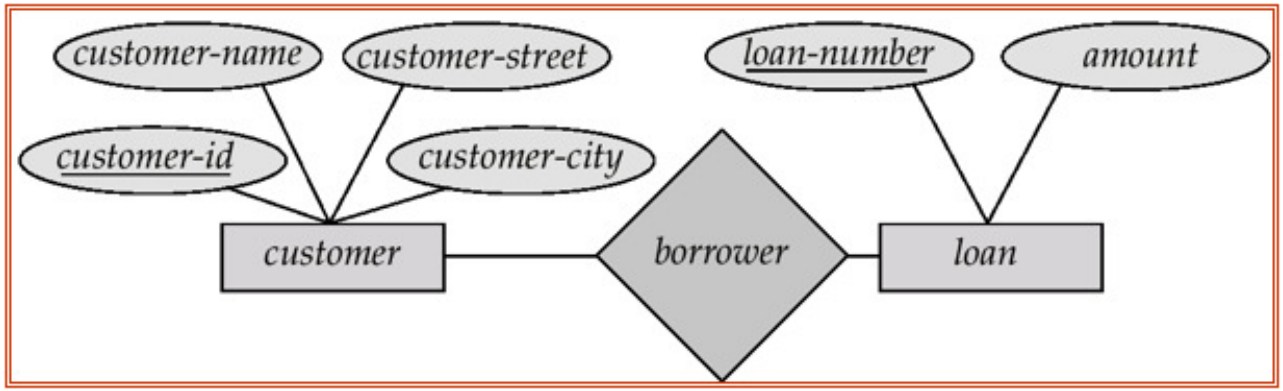
- Example of tabular data in the relational model

| *customer_id* | *customer_name* | *customer_street* | *customer_city* | *account_number* |
|---|---|---|---|---|
| 192-83-7465 | Johnson | 12 Alma St. | Palo Alto | A-101 |
| 192-83-7465 | Johnson | 12 Alma St. | Palo Alto | A-201 |
| 677-89-9011 | Hayes | 3 Main St. | Harrison | A-102 |
| 182-73-6091 | Turner | 123 Putnam St. | Stamford | A-305 |
| 321-12-3123 | Jones | 100 Main St. | Harrison | A-217 |
| 336-66-9999 | Lindsay | 175 Park Ave. | Pittsfield | A-222 |
| 019-28-3746 | Smith | 72 North St. | Rye | A-201 |

# The Entity-Relationship Model



- Models an enterprise as a collection of entities and relationships
  - Entity: a "thing" or "object" in the enterprise that is distinguishable from other objects
    - Described by a set of attributes
  - Relationship: an association among several entities
- Represented diagrammatically by an entity-relationship diagram:



# XML: Extensible Markup Language



- Defined by the WWW Consortium (W3C)
- Originally intended as a document markup language
- The ability to specify new tags, and to create nested tag structures made XML a great way to exchange data
- XML has become the basis for all new generation data interchange formats
- A wide variety of tools is available for parsing, browsing and querying XML documents/data

```
<bank>
   <account>
     <account_number> A-101 </account_number>
     <branch_name> Downtown </branch_name>
     <balance> 500 </balance>
   </account>
...
```

# Data Manipulation and Definition Languages



- Data Manipulation Language (DML)
  - Language for accessing and manipulating the data organized by the appropriate data model
    - Also known as query language
  - SQL is the most widely used query language
- Data Definition Language (DDL)
  - Specification notation for defining the database schema
  - DDL compiler generates a set of tables stored in the database

# SQL



- SQL: widely used non-procedural language
  - Example: find the name of the customer with customer-id 192-83-7465

```
select customer.customer_name
from customer
where customer.customer_id = '192-83-7465'
```

  - Example: creating the 'account' table

```
create table account (
   account-number char(10),
   balance integer )
```

- Application programs generally access databases through
  - A language extension to allow embedded SQL
  - An application program interface which allow SQL queries to be sent to a database

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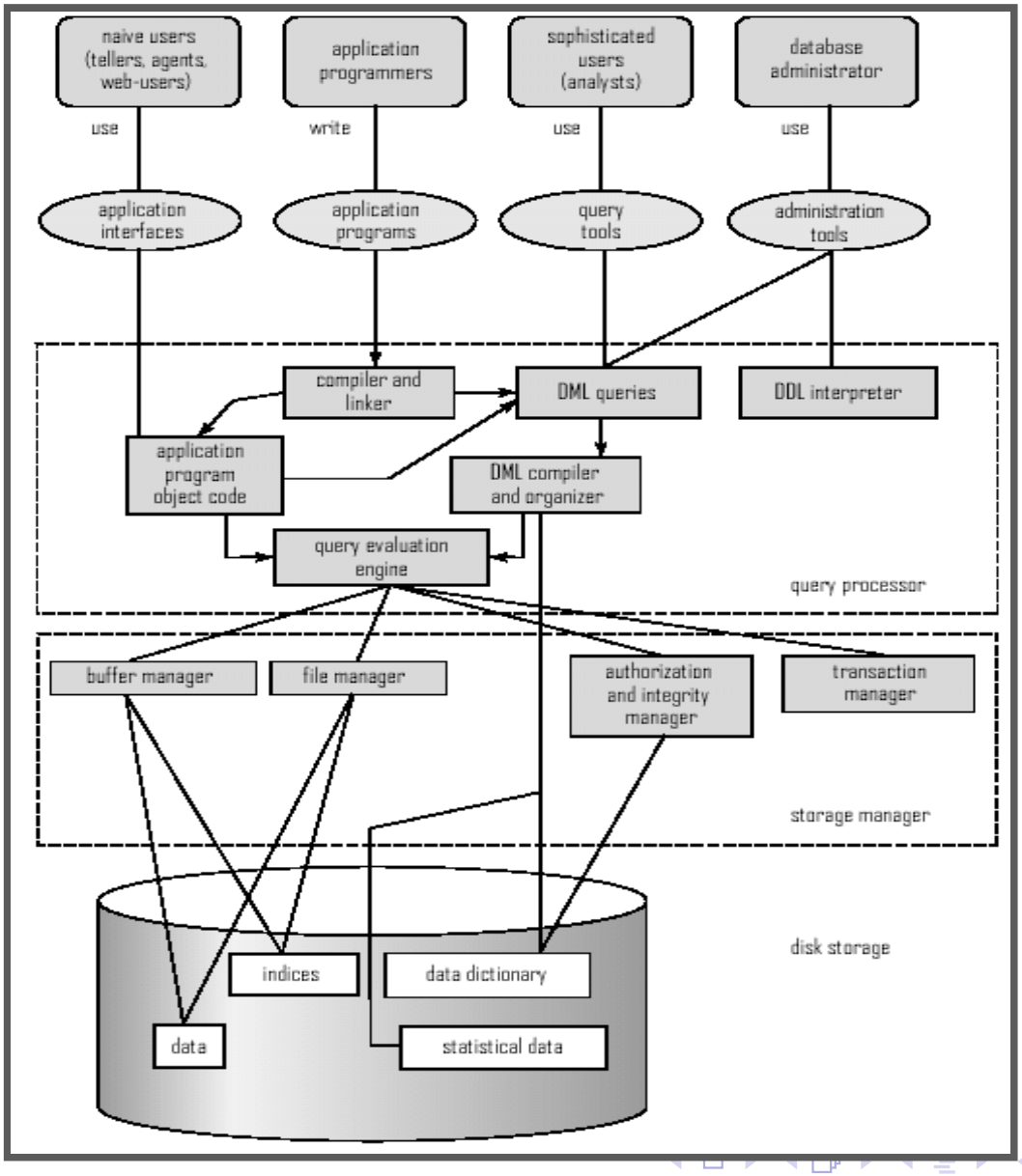
3 Architecture of a DBMS
- System Architecture
- DBMS Components

4 Database System Design

# Overall System Structure





# Database Architectures



The architecture of a database systems is greatly influenced by the underlying computer system on which the database is running:

- Centralized
- Client-server
- Parallel (multi-processor)
- Distributed

# Storage Management

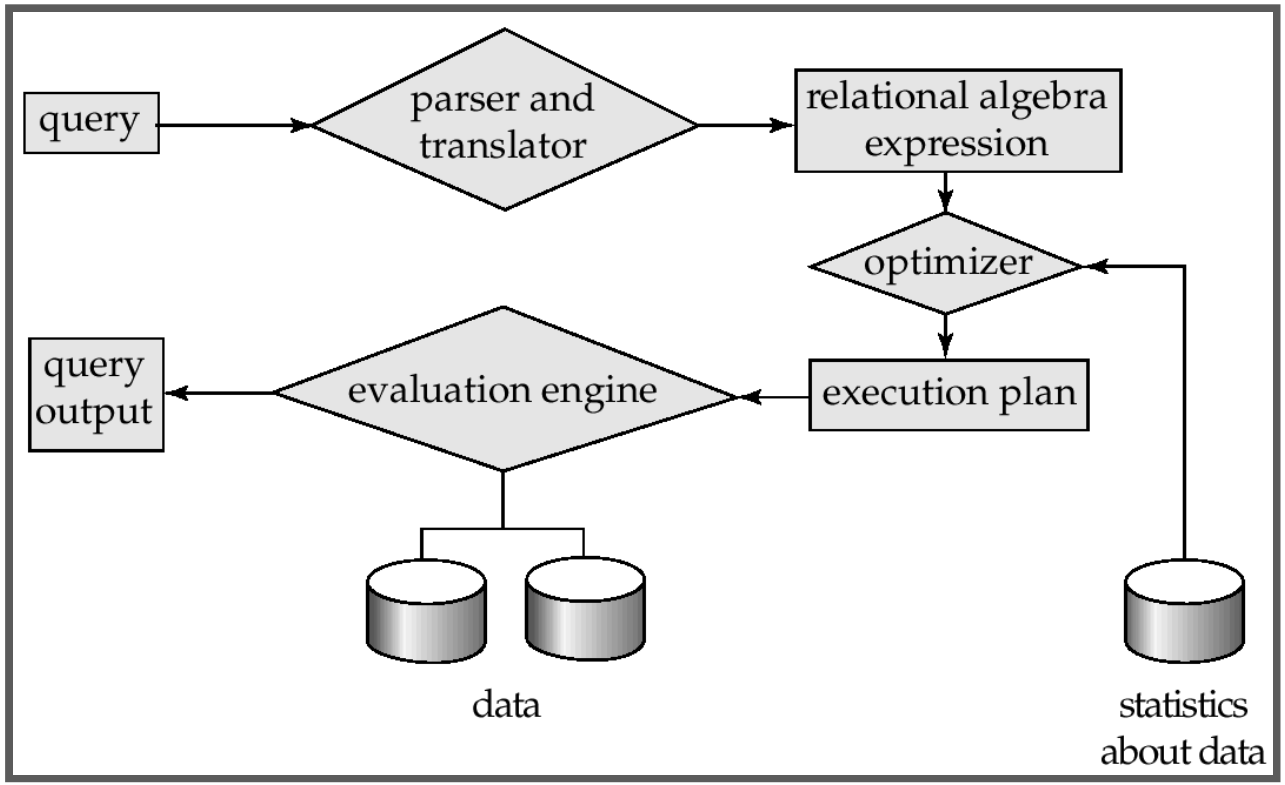


- Storage manager is a program module that provides the interface between the low-level data stored in the database and the application programs and queries submitted to the system.
- The storage manager is responsible to the following tasks:
  - Interaction with the file manager
  - Efficient storing, retrieving and updating of data
- Issues:
  - Storage access
  - File organization
  - Indexing and hashing

# Query Processing



1. Parsing and translation
2. Optimization
3. Evaluation



# Query Processing (cont.)



- Cost difference between a good and a bad way of evaluating a query can be enormous
- Need to estimate the cost of operations
  - Depends critically on statistical information about relations which the database must maintain
  - Need to estimate statistics for intermediate results to compute cost of complex expressions
- Alternative ways of evaluating a given query
  - Equivalent expressions
  - Different algorithms for each operation

# Transaction Management



- A transaction is a collection of operations that performs a single logical function in a database application
- Transaction-management component ensures that the database remains in a consistent (correct) state despite system failures (e.g., power failures and operating system crashes) and transaction failures.
- Concurrency-control manager controls the interaction among the concurrent transactions, to ensure the consistency of the database.

# Outline

# Database Design

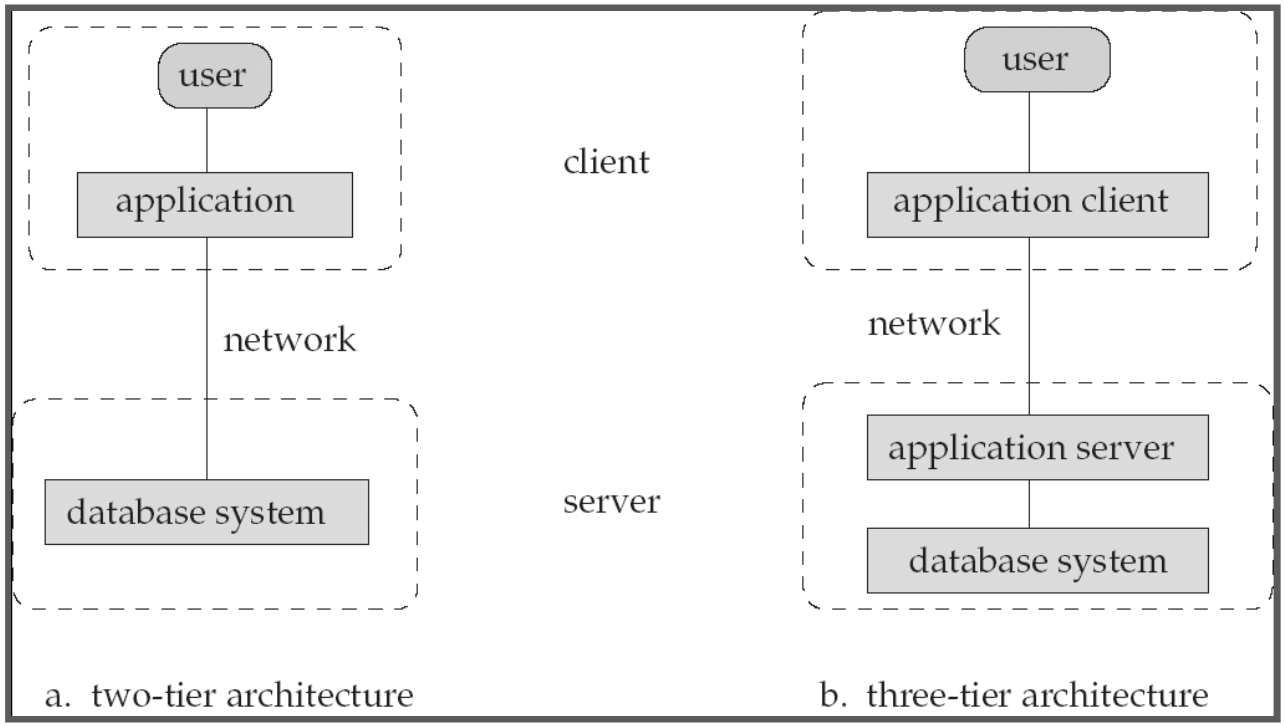


The process of designing the general structure of the database:

- Logical Design - Deciding on the database schema. Database design requires that we find a "good" collection of relation schemas.
  - What attributes should we record in the database?
  - What relation schemas should we have and how should the attributes be distributed among the various relation schemas?
- Physical Design - Deciding on the physical layout of the database

# Application Architectures





# Database Users



Users are differentiated by the way they expect to interact with the system

- Application programmers - interact with system through DML calls
- Sophisticated users - form requests in a database query language
- Specialized users - write specialized database applications that do not fit into the traditional data processing framework
- Naïve users - invoke one of the permanent application programs that have been written previously
  - Examples, people accessing database over the web, bank tellers, clerical staff

# Database Administrator



- Coordinates all the activities of the database system; the database administrator has a good understanding of the enterprise's information resources and needs.
- Database administrator's duties include:
  - Schema definition
  - Storage structure and access method definition
  - Schema and physical organization modification
  - Granting user authority to access the database
  - Specifying integrity constraints
  - Acting as liaison with users
  - Monitoring performance and responding to changes in requirements



End of Chapter 1