



# Chapter 1: Introduction

**Database System Concepts, 6<sup>th</sup> Ed.**

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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: 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 can be very large.
- Databases touch all aspects of our lives



# University Database Example

- Application program examples
  - Add new students, instructors, and courses
  - Register students for courses, and generate class rosters
  - Assign grades to students, compute grade point averages (GPA) and generate transcripts
- 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
- Data isolation — multiple files and formats
- 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



# Drawbacks of using file systems to store data (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 access needed for performance
  - ▶ Uncontrolled concurrent accesses can lead to inconsistencies
    - Example: Two people reading a balance (say 100) and updating it by withdrawing money (say 50 each) 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**



# Data Models

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



# Relational Model

- Relational model (Chapter 2)
- Example of tabular data in the relational model

Columns

<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
10101	Srinivasan	Comp. Sci.	65000
58583	Califieri	History	62000
83821	Brandt	Comp. Sci.	92000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

Rows

(a) The *instructor* table



# A Sample Relational Database

<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
10101	Srinivasan	Comp. Sci.	65000
58583	Califieri	History	62000
83821	Brandt	Comp. Sci.	92000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

(a) The *instructor* table

<i>dept_name</i>	<i>building</i>	<i>budget</i>
Comp. Sci.	Taylor	100000
Biology	Watson	90000
Elec. Eng.	Taylor	85000
Music	Packard	80000
Finance	Painter	120000
History	Painter	50000
Physics	Watson	70000

(b) The *department* table





# Data Definition Language (DDL)

- Specification notation for defining the database schema

Example:        **create table** *instructor* (  
                              *ID*              **char**(5),  
                              *name*          **varchar**(20),  
                              *dept\_name* **varchar**(20),  
                              *salary*      **numeric**(8,2))

- DDL compiler generates a set of table templates stored in a ***data dictionary***
- Data dictionary contains metadata (i.e., data about data)
  - Database schema
  - Integrity constraints
    - ▶ Primary key (ID uniquely identifies instructors)
    - ▶ Referential integrity (**references** constraint in SQL)
      - e.g. *dept\_name* value in any *instructor* tuple must appear in *department* relation
  - Authorization



# SQL

- **SQL**: widely used non-procedural language
  - Example: Find the name of the instructor with ID 22222

```
select   name
from    instructor
where   instructor.ID = '22222'
```
  - Example: Find the ID and building of instructors in the Physics dept.

```
select instructor.ID, department.building
from   instructor, department
where  instructor.dept_name = department.dept_name and
        department.dept_name = 'Physics'
```
- Application programs generally access databases through one of
  - Language extensions to allow embedded SQL
  - Application program interface (e.g., ODBC/JDBC) which allow SQL queries to be sent to a database
- Chapters 3, 4 and 5



# Database Design?

- Is there any problem with this design?

<i>ID</i>	<i>name</i>	<i>salary</i>	<i>dept_name</i>	<i>building</i>	<i>budget</i>
22222	Einstein	95000	Physics	Watson	70000
12121	Wu	90000	Finance	Painter	120000
32343	El Said	60000	History	Painter	50000
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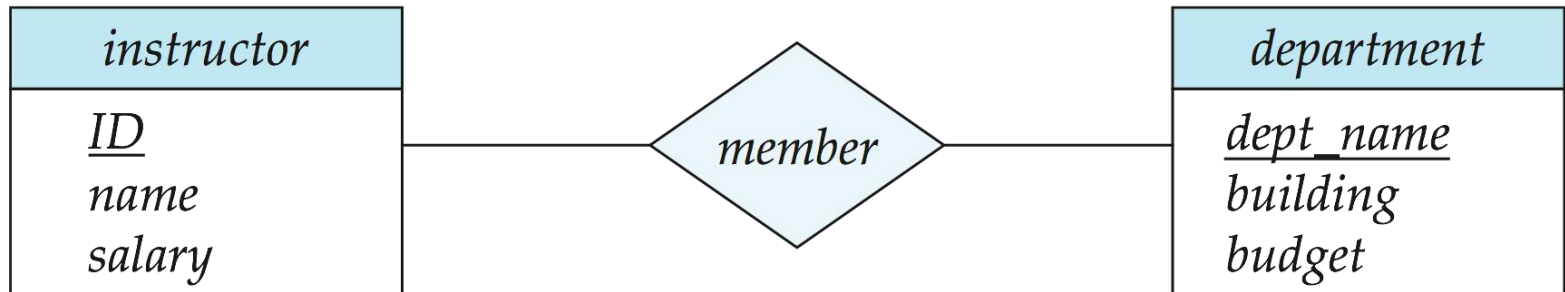
# Design Approaches

- Normalization Theory (Chapter 8)
  - Formalize what designs are bad, and test for them
- Entity Relationship Model (Chapter 7)
  - 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*:



# 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*:



**What happened to dept\_name of instructor and student?**



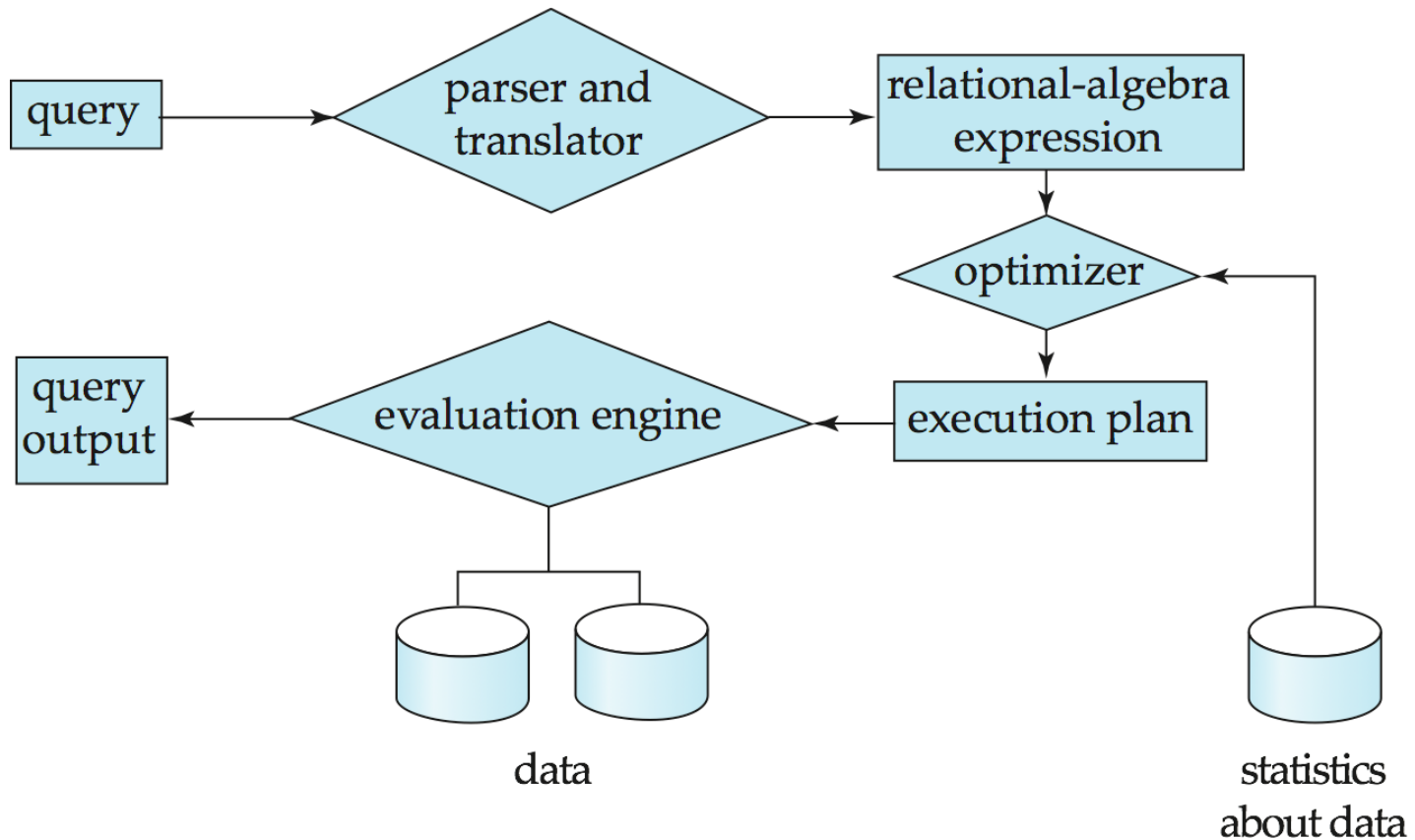
# Storage Management

- **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





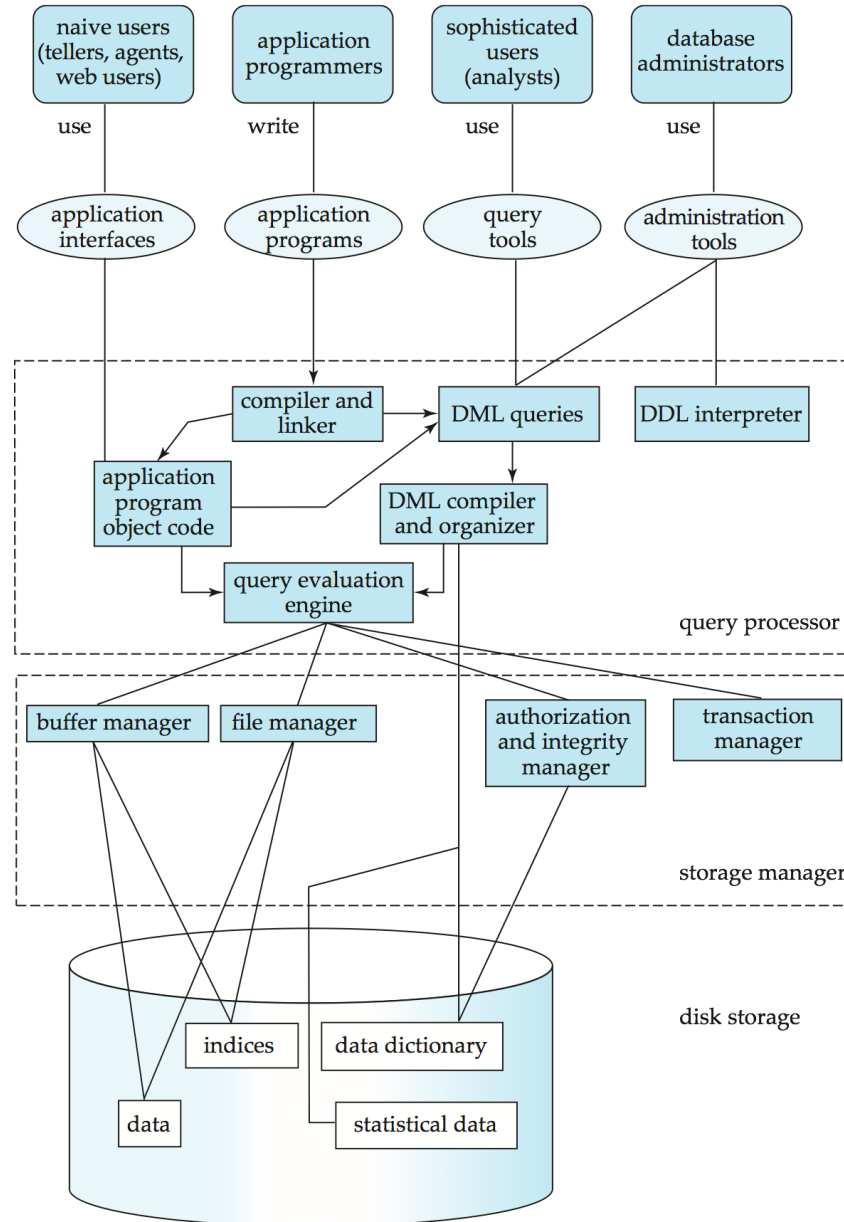
# Transaction Management

- What if the system fails?
- What if more than one user is concurrently updating the same data?
- 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.





# Database System Internals





# Database Architecture

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



# History of Database Systems

- 1950s and early 1960s:
  - Data processing using magnetic tapes for storage
    - ▶ Tapes provided only sequential access
  - Punched cards for input
- Late 1960s and 1970s:
  - Hard disks allowed direct access to data
  - Network and hierarchical data models in widespread use
  - Ted Codd defines the relational data model
    - ▶ Would win the ACM Turing Award for this work
    - ▶ IBM Research begins System R prototype
    - ▶ UC Berkeley begins Ingres prototype
  - High-performance (for the era) transaction processing



# History (cont.)

- 1980s:
  - Research relational prototypes evolve into commercial systems
    - ▶ SQL becomes industrial standard
  - Parallel and distributed database systems
  - Object-oriented database systems
- 1990s:
  - Large decision support and data-mining applications
  - Large multi-terabyte data warehouses
  - Emergence of Web commerce
- Early 2000s:
  - XML and XQuery standards
  - Automated database administration
- Later 2000s:
  - Giant data storage systems
    - ▶ Google BigTable, Yahoo PNuts, Amazon, ..



# End of Chapter 1



# Figure 1.02

<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
22222	Einstein	Physics	95000
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(b) The *department* table

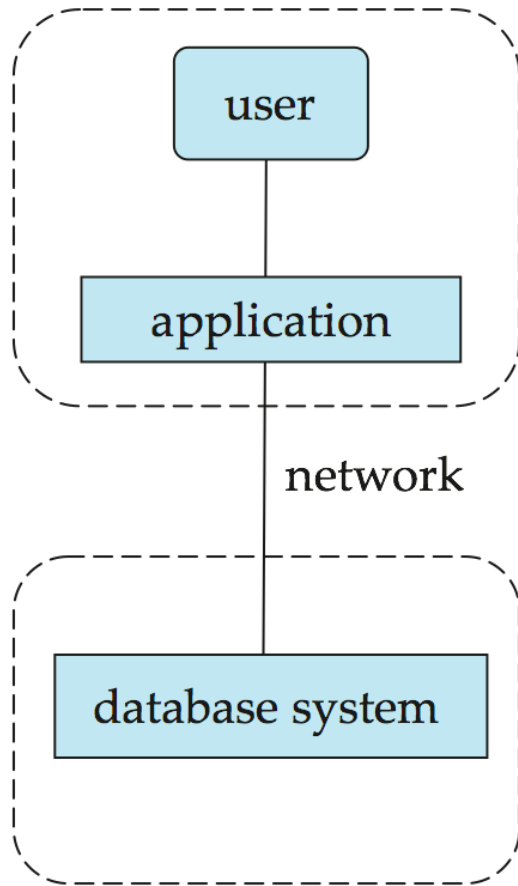


## Figure 1.04

<i>ID</i>	<i>name</i>	<i>salary</i>	<i>dept_name</i>	<i>building</i>	<i>budget</i>
22222	Einstein	95000	Physics	Watson	70000
12121	Wu	90000	Finance	Painter	120000
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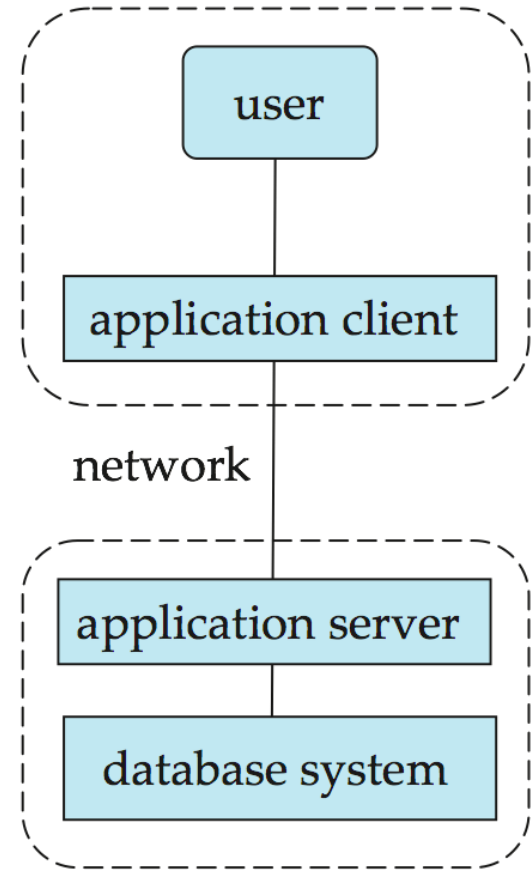


# Figure 1.06



(a) Two-tier architecture

client



server

(b) Three-tier architecture