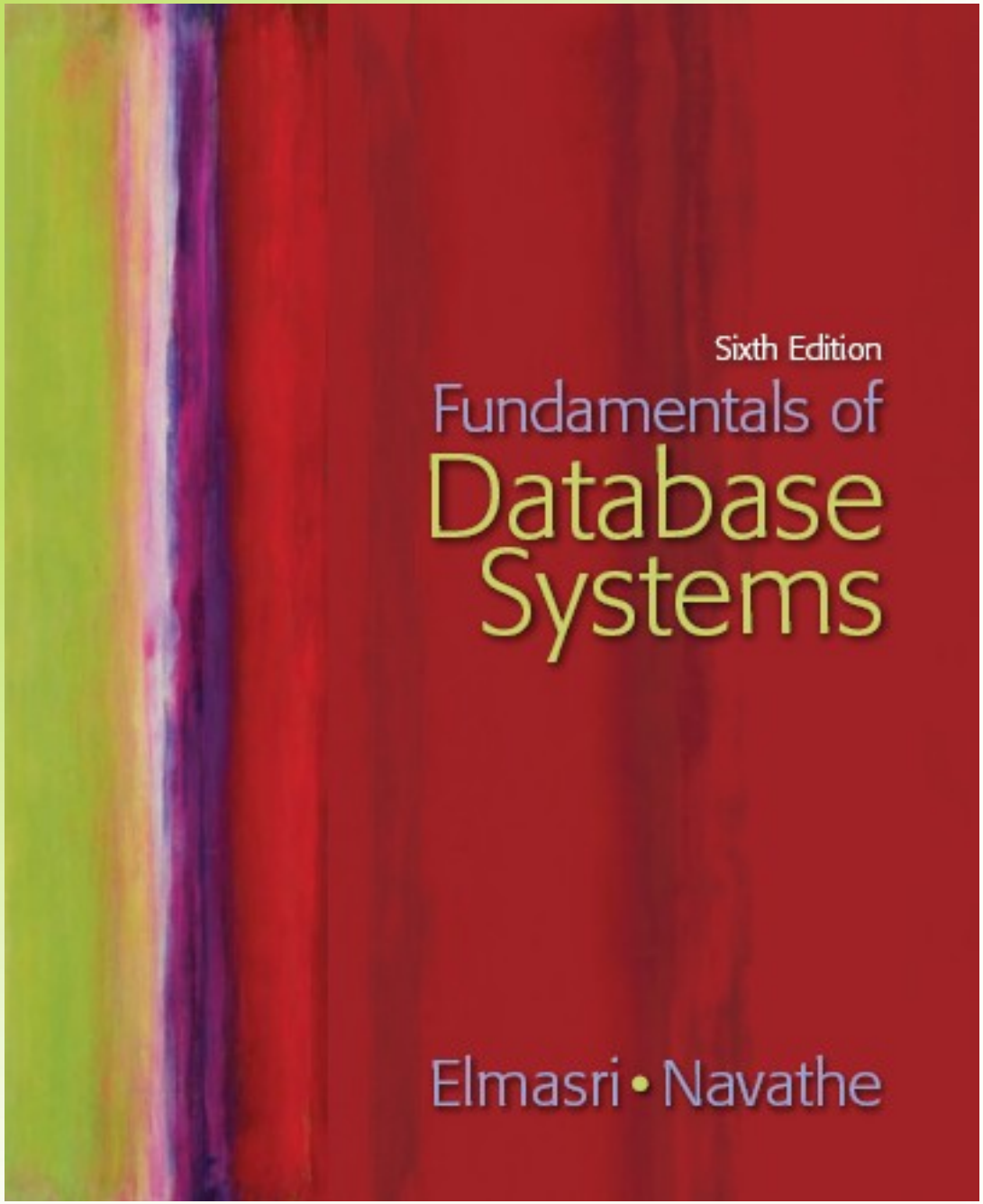
Chapter 1

Databases and Database Users



Chapter 1 Outline

- Introduction
- An Example
- Characteristics of the Database Approach
- Actors on the Scene
- Workers behind the Scene
- Advantages of Using the DBMS Approach
- A Brief History of Database Applications
- When Not to Use a DBMS

Overview

- **Traditional database applications**
  - Store textual or numeric information
- **Multimedia databases**
  - Store images, audio clips, and video streams digitally
- **Geographic information systems (GIS)**
  - Store and analyze maps, weather data, and satellite images

Overview (cont'd.)

- **Data warehouses and online analytical processing (OLAP) systems**
  - Extract and analyze useful business information from very large databases
  - Support decision making
- **Real-time and active database technology**
  - Control industrial and manufacturing processes

Introduction

- **Database**
  - Collection of related data
    - Known facts that can be recorded and that have implicit meaning.
  - **Miniworld** or **universe of discourse (UoD)**
  - Represents some aspect of the real world
  - Logically coherent collection of data with inherent meaning
  - Built for a specific purpose

Introduction (cont'd.)

- Example of a large commercial database
  - Amazon.com
- **Database management system (DBMS)**
  - Collection of programs enables users to create and maintain a database
  1. **Defining** a database
     - Specify the data types, structures, and constraints of the data to be stored

Introduction (cont'd.)

- **Meta-data**
  - Database definition or descriptive information
  - Stored by the DBMS in the form of a database catalog or dictionary

2. **Manipulating** a database
   - Query and update the database miniworld
   - Generate reports

Introduction (cont'd.)

3. **Sharing** a database
   - Allow multiple users and programs to access the database simultaneously.
4. **Application program**
   - Accesses database by sending queries to DBMS
- **Query**
  - Causes some data to be retrieved

Introduction (cont'd.)

5. **Transaction**
   - May cause some data to be read and some data to be written into the database
6. **Protection** includes:
   - System protection
   - Security protection
7. **Maintain** the database system
   - Allow the system to evolve as requirements change over time

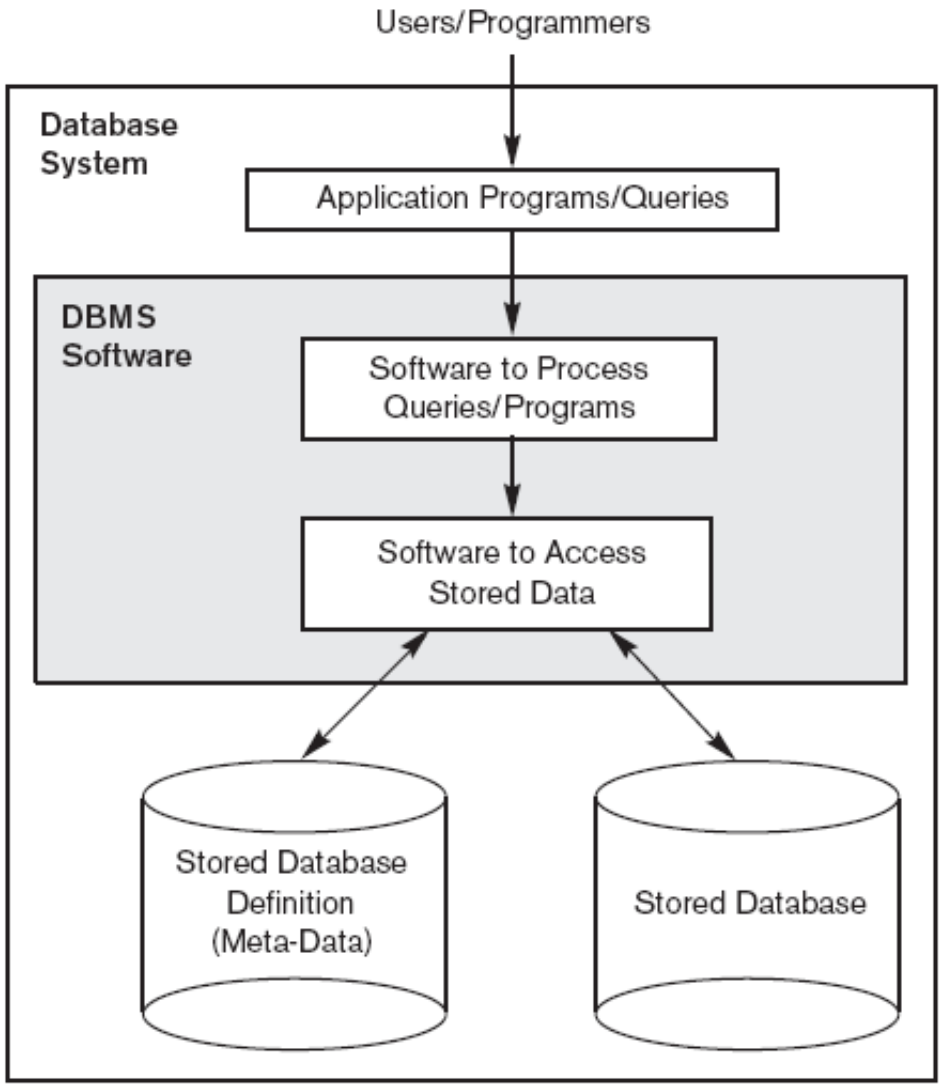


Figure 1.1
A simplified database system environment.

An Example

- UNIVERSITY database
  - Information concerning students, courses, and grades in a university environment
- **Data records**
  - STUDENT
  - COURSE
  - SECTION
  - GRADE_REPORT
  - PREREQUISITE

An Example (cont'd.)

- Specify structure of records of each file by specifying **data type** for each **data element**
  - String of alphabetic characters
  - Integer
  - Etc.

An Example (cont'd.)

- Construct UNIVERSITY database
  - Store data to represent each student, course, section, grade report, and prerequisite as a record in appropriate file
- Relationships among the records
- Manipulation involves querying and updating

STUDENT

Name	Student_number	Class	Major
Smith	17	1	CS
Brown	8	2	CS

COURSE

Course_name	Course_number	Credit_hours	Department
Intro to Computer Science	CS1310	4	CS
Data Structures	CS3320	4	CS
Discrete Mathematics	MATH2410	3	MATH
Database	CS3380	3	CS

SECTION

Section_identifier	Course_number	Semester	Year	Instructor
85	MATH2410	Fall	07	King
92	CS1310	Fall	07	Anderson
102	CS3320	Spring	08	Knuth
112	MATH2410	Fall	08	Chang
119	CS1310	Fall	08	Anderson
135	CS3380	Fall	08	Stone

GRADE_REPORT

Student_number	Section_identifier	Grade
17	112	B
17	119	C
8	85	A
8	92	A
8	102	B
8	135	A

PREREQUISITE

Course_number	Prerequisite_number
CS3380	CS3320
CS3380	MATH2410
CS3320	CS1310

Figure 1.2
A database that stores student and course information.

An Example (cont'd.)

- Examples of queries:
  - Retrieve the transcript
  - List the names of students who took the section of the ‘Database’ course offered in fall 2008 and their grades in that section
  - List the prerequisites of the ‘Database’ course

An Example (cont'd.)

- Examples of updates:
  - Change the class of ‘Smith’ to class 1
  - Create a new section for the ‘Database’ course for this semester
  - Enter a grade of ‘A’ for ‘Smith’ in the ‘Database’ section of last semester

An Example (cont'd.)

- Phases for designing a database:
  - **Requirements specification and analysis**
  - **Conceptual design**
  - **Logical design**
  - **Physical design**

Characteristics of the Database Approach

- Traditional **file processing**
  - Each user defines and implements the files needed for a specific software application.
- Database approach
  - Single repository maintains data that is defined once and then accessed by various users.

Characteristics of the Database Approach (cont'd.)

- Main characteristics of database approach
  1. Self-describing nature of a database system
  2. Insulation between programs and data, and data abstraction
  3. Support of multiple views of the data
  4. Sharing of data and multiuser transaction processing

Self-Describing Nature of a Database System

- Database system contains complete definition of structure and constraints
- **Meta-data**
  - Describes structure of the database
- Database catalog used by:
  - DBMS software
  - Database users who need information about database structure

Insulation Between Programs and Data

- **Program-data independence**
  - Structure of data files is stored in DBMS catalog separately from access programs
- Program-operation independence
  - **Operations** specified in two parts:
    - Interface includes operation name and data types of its arguments
    - Implementation can be changed without affecting the interface

Data Abstraction

- **Data abstraction**
  - Allows program-data independence and program-operation independence
- **Conceptual representation** of data
  - Does not include details of how data is stored or how operations are implemented
- **Data model**
  - Type of data abstraction used to provide conceptual representation

RELATIONS

Relation_name	No_of_columns
STUDENT	4
COURSE	4
SECTION	5
GRADE_REPORT	3
PREREQUISITE	2

COLUMNS

Column_name	Data_type	Belongs_to_relation
Name	Character (30)	STUDENT
Student_number	Character (4)	STUDENT
Class	Integer (1)	STUDENT
Major	Major_type	STUDENT
Course_name	Character (10)	COURSE
Course_number	XXXXNNNN	COURSE
….	….	…..
….	….	…..
….	….	…..
Prerequisite_number	XXXXNNNN	PREREQUISITE

Note: Major_type is defined as an enumerated type with all known majors.
XXXXNNNN is used to define a type with four alpha characters followed by four digits.

Figure 1.3
An example of a database catalog for the database in Figure 1.2.

Support of Multiple Views of the Data

- **View**
  - Subset of the database
  - Contains **virtual data** derived from the database files but is not explicitly stored
- Multiuser DBMS
  - Users have a variety of distinct applications
  - Must provide facilities for defining multiple views

Sharing of Data and Multiuser Transaction Processing

- Allow multiple users to access the database at the same time
- **Concurrency control software**
  - Ensure that several users trying to update the same data do so in a controlled manner
    - Result of the updates is correct
- **Online transaction processing (OLTP) application**

Sharing of Data and Multiuser Transaction Processing (cont'd.)

- **Transaction**
  - Central to many database applications
  - Executing program or process that includes one or more database
  - **Isolation** property
    - Each transaction appears to execute in isolation from other transactions
  - **Atomicity** property
    - Either all the database operations in a transaction are executed or none are

Actors on the Scene

- **Database administrators (DBA)** are responsible for:
  - Authorizing access to the database
  - Coordinating and monitoring its use
  - Acquiring software and hardware resources
- **Database designers** are responsible for:
  - Identifying the data to be stored
  - Choosing appropriate structures to represent and store this data

Actors on the Scene (cont'd.)

- **End users**
  - People whose jobs require access to the database
  - Types
    - **Casual end users**
    - **Naive** or **parametric end users**
    - **Sophisticated end users**
    - **Standalone users**

Actors on the Scene (cont'd.)

- **System analysts**
  - Determine requirements of end users
- **Application programmers**
  - Implement these specifications as programs

Workers behind the Scene

- **DBMS system designers and implementers**
  - Design and implement the DBMS modules and interfaces as a software package
- **Tool developers**
  - Design and implement **tools**
- **Operators and maintenance personnel**
  - Responsible for running and maintenance of hardware and software environment for database system

Advantages of Using the DBMS Approach

- Controlling redundancy
  - **Data normalization**
  - **Denormalization**
    - Sometimes necessary to use **controlled redundancy** to improve the performance of queries
- Restricting unauthorized access
  - Security and authorization subsystem
  - Privileged software

Advantages of Using the DBMS Approach (cont'd.)

- Providing **persistent** storage for program objects
  - Complex object in C++ can be stored permanently in an object-oriented DBMS
  - **Impedance mismatch problem**
    - Object-oriented database systems typically offer data structure **compatibility**

Advantages of Using the DBMS Approach (cont'd.)

- Providing storage structures and search techniques for efficient query processing
  - **Indexes**
  - **Buffering** and **caching**
  - **Query processing and optimization**

Advantages of Using the DBMS Approach (cont'd.)

- Providing backup and recovery
  - **Backup and recovery subsystem** of the DBMS is responsible for recovery
- Providing multiple user interfaces
  - **Graphical user interfaces (GUIs)**
- Representing complex relationships among data
  - May include numerous varieties of data that are interrelated in many ways

Advantages of Using the DBMS Approach (cont'd.)

- Enforcing **integrity constraints**
  - **Referential integrity** constraint
    - Every section record must be related to a course record
  - **Key** or **uniqueness** constraint
    - Every course record must have a unique value for Course_number
  - **Business rules**
  - **Inherent rules** of the data model

Advantages of Using the DBMS Approach (cont'd.)

- Permitting inferencing and actions using rules
  - **Deductive database systems**
    - Provide capabilities for defining deduction **rules**
    - Inferencing new information from the stored database facts
  - **Trigger**
    - Rule activated by updates to the table
  - **Stored procedures**
    - More involved procedures to enforce rules

Advantages of Using the DBMS Approach (cont'd.)

- Additional implications of using the database approach
  - Reduced application development time
  - Flexibility
  - Availability of up-to-date information
  - Economies of scale

A Brief History of Database Applications

- Early database applications using hierarchical and network systems
  - Large numbers of records of similar structure
- Providing data abstraction and application flexibility with relational databases
  - Separates physical storage of data from its conceptual representation
  - Provides a mathematical foundation for data representation and querying

A Brief History of Database Applications (cont'd.)

- Object-oriented applications and the need for more complex databases
  - Used in specialized applications: engineering design, multimedia publishing, and manufacturing systems
- Interchanging data on the Web for e-commerce using XML
  - Extended markup language (XML) primary standard for interchanging data among various types of databases and Web pages

A Brief History of Database Applications (cont'd.)

- Extending database capabilities for new applications
  - Extensions to better support specialized requirements for applications
  - **Enterprise resource planning (ERP)**
  - **Customer relationship management (CRM)**
- Databases versus information retrieval
  - **Information retrieval (IR)**
    - Deals with books, manuscripts, and various forms of library-based articles

When Not to Use a DBMS

- More desirable to use regular files for:
  - Simple, well-defined database applications not expected to change at all
  - Stringent, real-time requirements that may not be met because of DBMS overhead
  - Embedded systems with limited storage capacity
  - No multiple-user access to data

Summary

- Database
  - Collection of related data (recorded facts)
- DBMS
  - Generalized software package for implementing and maintaining a computerized database
- Several categories of database users
- Database applications have evolved
  - Current trends: IR, Web