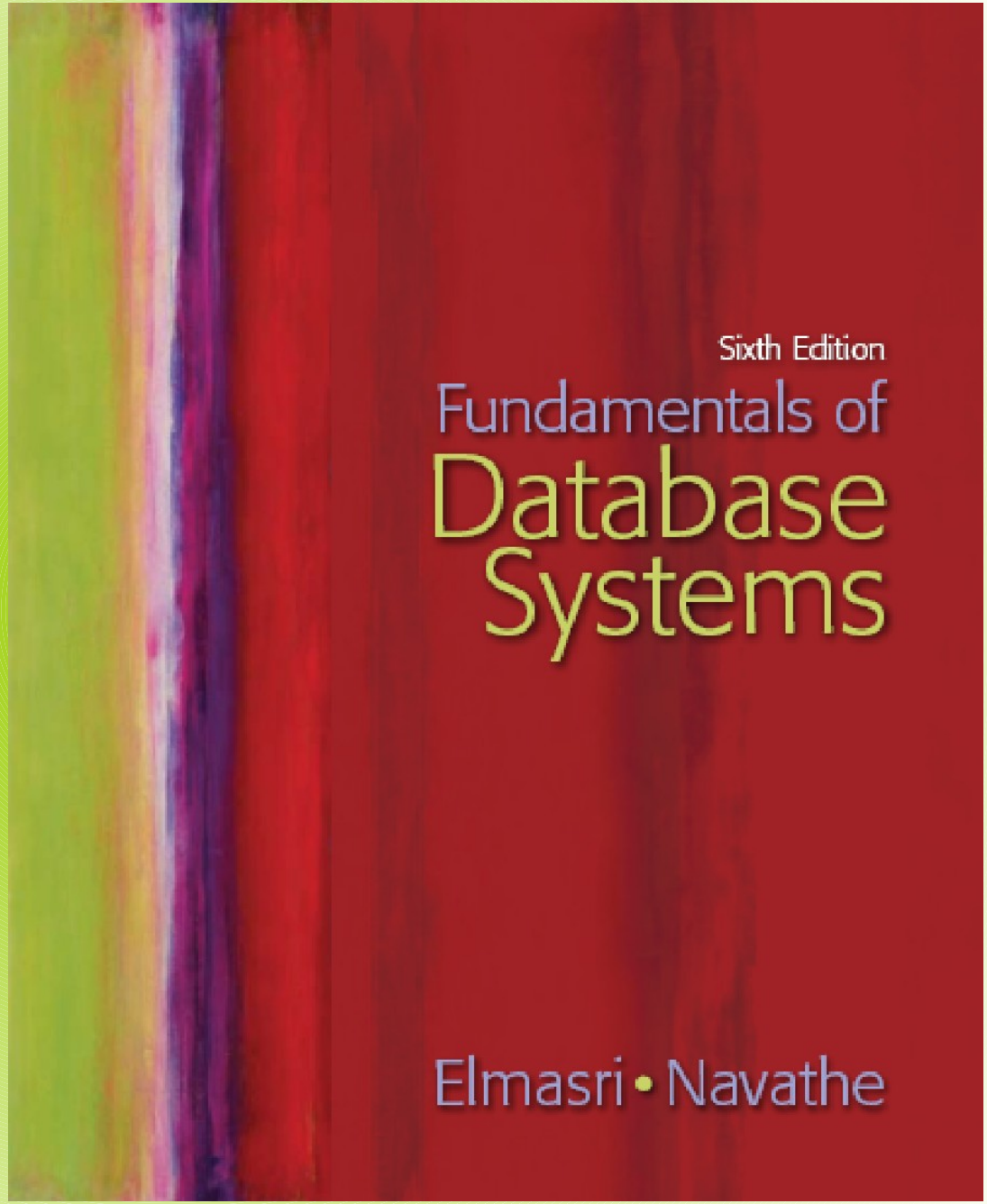
Chapter 1

Databases and Database Users



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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

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

Manipulating a database

- Query and update the database miniworld
- Generate reports

Introduction (cont'd.)

Sharing a database

Allow multiple users and programs to access the database simultaneously

Application program

Accesses database by sending queries to DBMS

Query

Causes some data to be retrieved

Introduction (cont'd.)

Transaction

May cause some data to be read and some data to be written into the database

Protection includes:

System protection

Security protection

Maintain the database system

Allow the system to evolve as requirements change over time

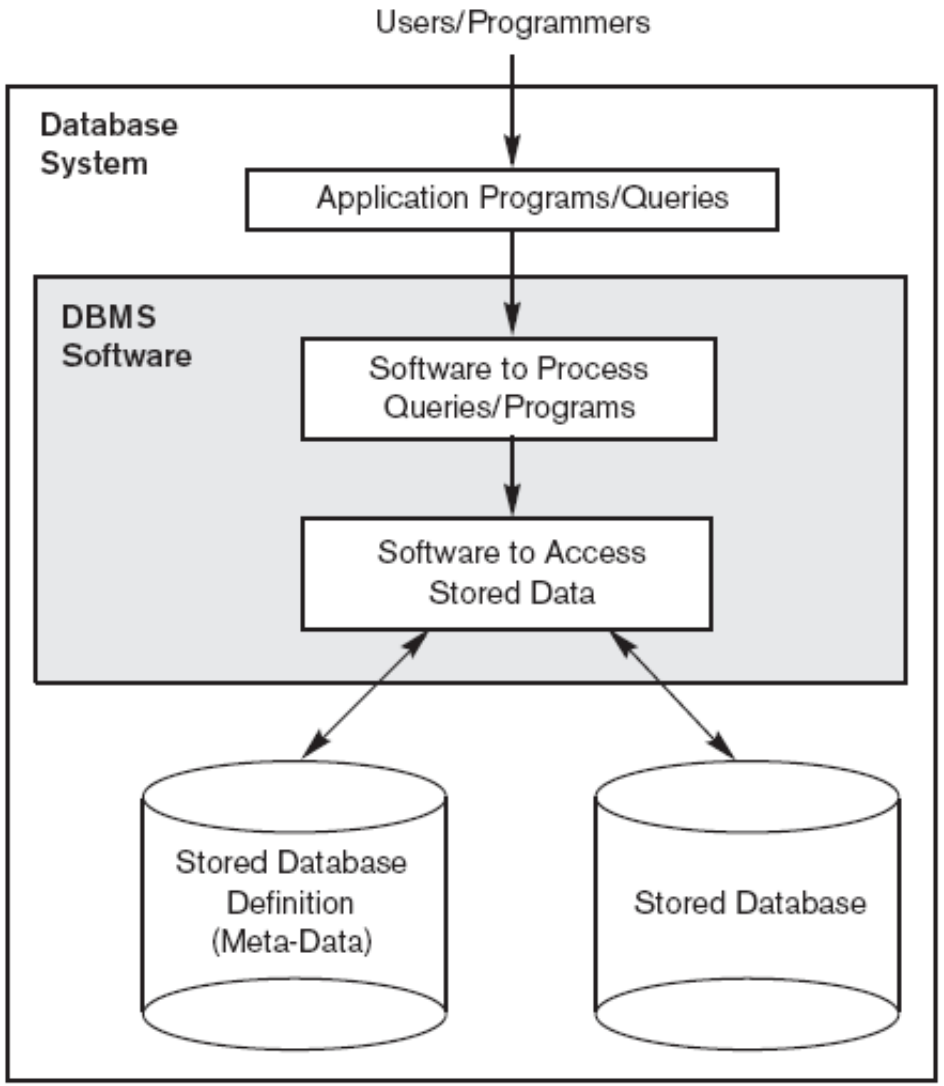

Figure 1.1
A simplified database system environment.

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

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 spring 2021 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 sophomore
- 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**

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.

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

- Self-describing nature of a database system
- Insulation between programs and data, and data abstraction
- Support of multiple views of the data
- 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