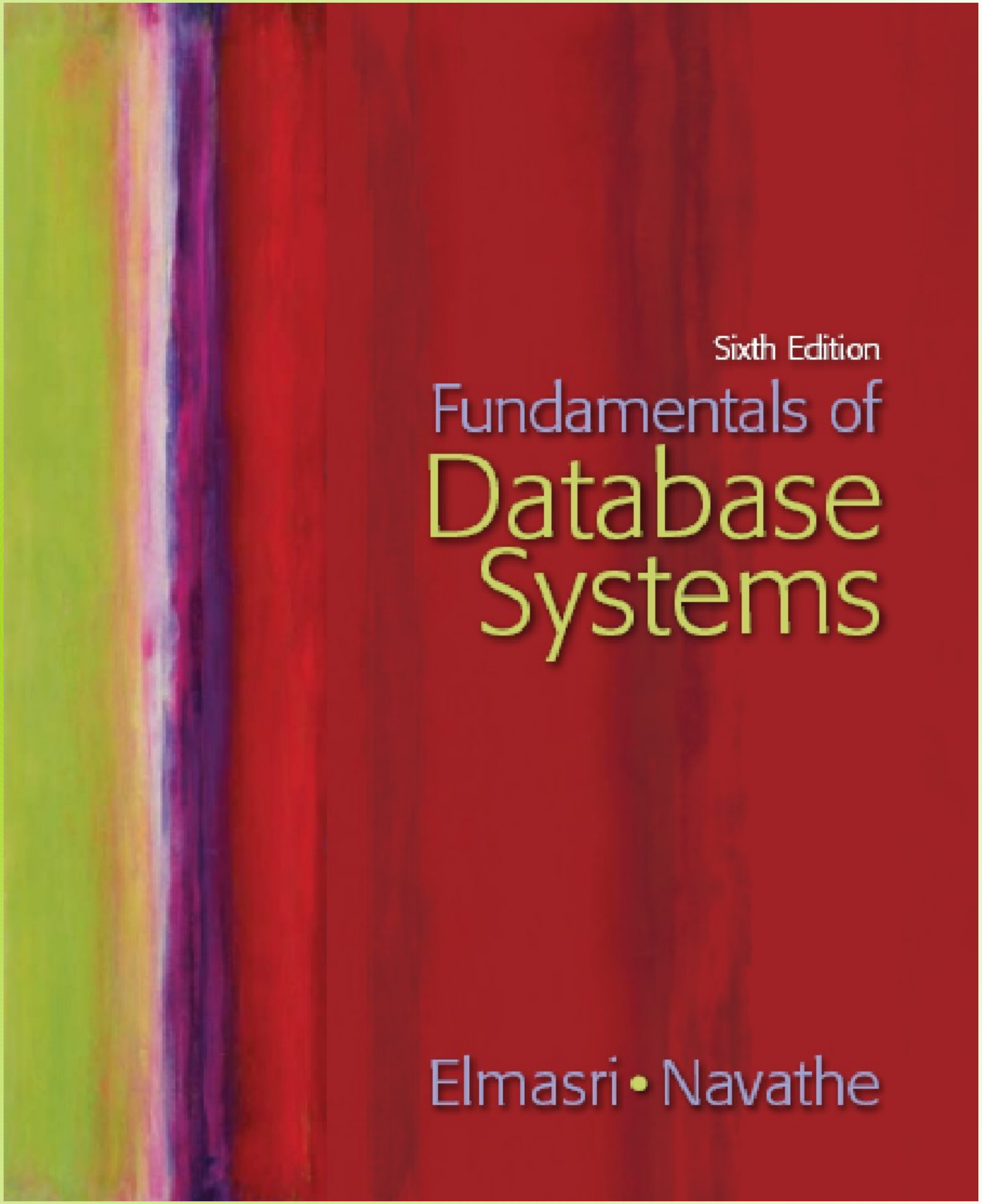
Chapter 2

Database System Concepts and Architecture



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Chapter 2 Outline

Data Models, Schemas, and Instances

Three-Schema Architecture and Data Independence

Database Languages and Interfaces

The Database System Environment

Centralized and Client/Server Architectures
for DBMSs

Classification of Database Management Systems

Database System Concepts and Architecture

Basic client/server DBMS architecture

- **Client module**
- **Server module**

Data Models, Schemas, and Instances

Data abstraction

- Suppression of details of data organization and storage
- Highlighting of the essential features for an improved understanding of data

Data Models, Schemas, and Instances (cont'd.)

Data model

- Collection of concepts that describe the structure of a database
- Provides means to achieve data abstraction
- **Basic operations**
  - Specify retrievals and updates on the database
- **Dynamic aspect** or **behavior** of a database application
  - Allows the database designer to specify a set of valid operations allowed on database objects

Categories of Data Models

High-level or **conceptual data models**

Close to the way many users perceive data

Low-level or **physical data models**

Describe the details of how data is stored on computer storage media

Representational data models

Easily understood by end users

Also similar to how data organized in computer storage

Categories of Data Models (cont'd.)

- **Entity**
  - Represents a real-world object or concept
- **Attribute**
  - Represents some property of interest
  - Further describes an entity
- **Relationship** among two or more entities
  - Represents an association among the entities
  - **Entity-Relationship model**

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Categories of Data Models (cont'd.)

Relational data model

Used most frequently in traditional commercial DBMSs

Object data model

New family of higher-level implementation data models

Closer to conceptual data models

Categories of Data Models (cont'd.)

Physical data models

Describe how data is stored as files in the computer

Access path

- Structure that makes the search for particular database records efficient

Index

- Example of an access path
- Allows direct access to data using an index term or a keyword

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Schemas, Instances, and Database State

Database schema

Description of a database

Schema diagram

Displays selected aspects of schema

Schema construct

Each object in the schema

Database state or **snapshot**

Data in database at a particular moment in time

Schemas, Instances, and Database State (cont'd.)

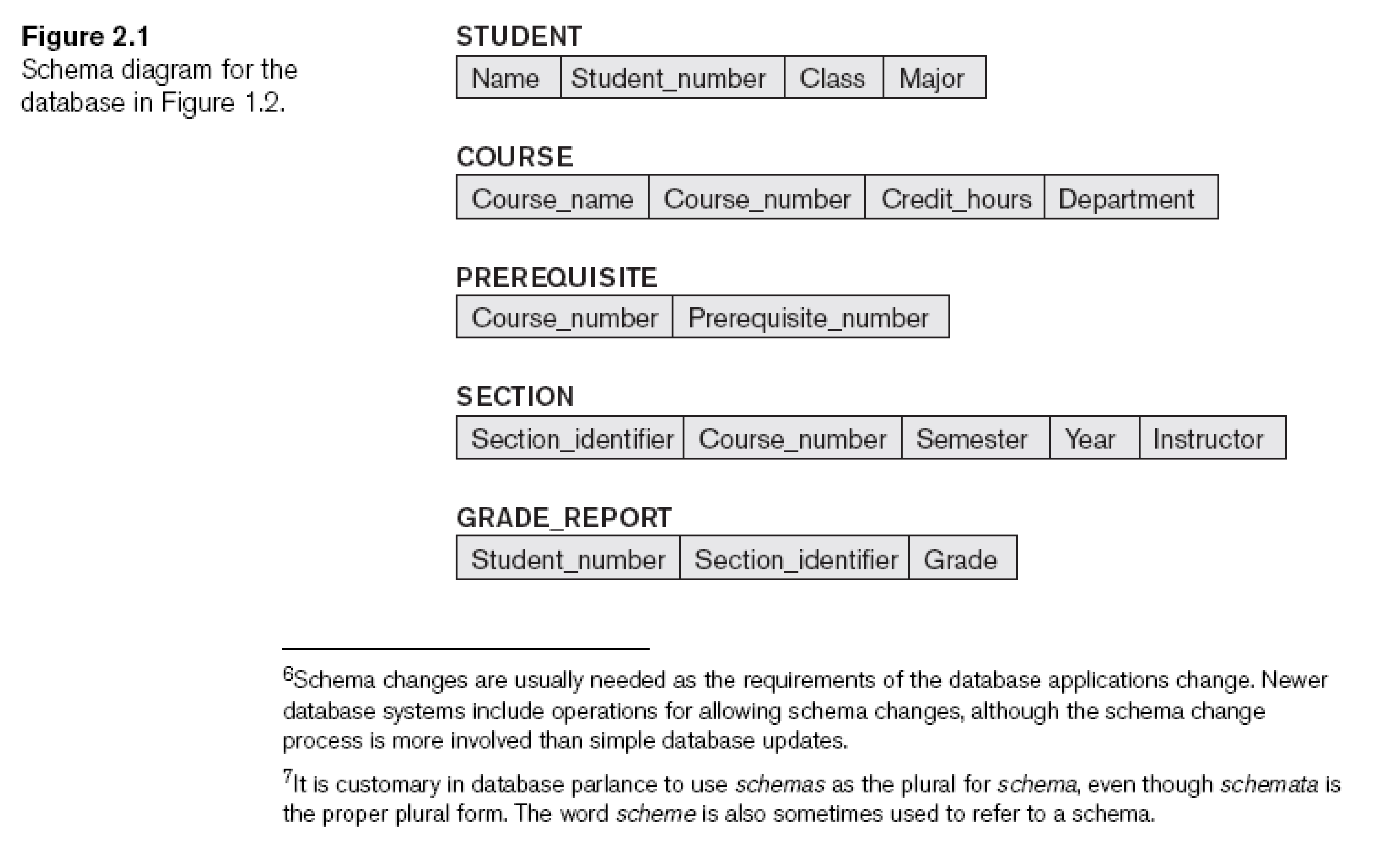

Figure 2.1
Schema diagram for the database in Figure 1.2.

STUDENT

Name	Student_number	Class	Major

COURSE

Course_name	Course_number	Credit_hours	Department

PREREQUISITE

Course_number	Prerequisite_number

SECTION

Section_identifier	Course_number	Semester	Year	Instructor

GRADE_REPORT

Student_number	Section_identifier	Grade

[6] Schema changes are usually needed as the requirements of the database applications change. Newer database systems include operations for allowing schema changes, although the schema change process is more involved than simple database updates.

[7] It is customary in database parlance to use *schemas* as the plural for *schema*, even though *schemata* is the proper plural form. The word *scheme* is also sometimes used to refer to a schema.

Schemas, Instances, and Database State (cont'd.)

Define a new database

Specify database schema to the DBMS

Initial state

Populated or **loaded** with the initial data

Valid state

Satisfies the structure and constraints specified in the schema

Schemas, Instances, and Database State (cont'd.)

Schema evolution

Changes applied to schema as application requirements change

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Three-Schema Architecture and Data Independence

Internal level

Describes physical storage structure of the database

Conceptual level

Describes structure of the whole database for a community of users

External or **view level**

Describes part of the database that a particular user group is interested in

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Three-Schema Architecture and Data Independence (cont'd.)

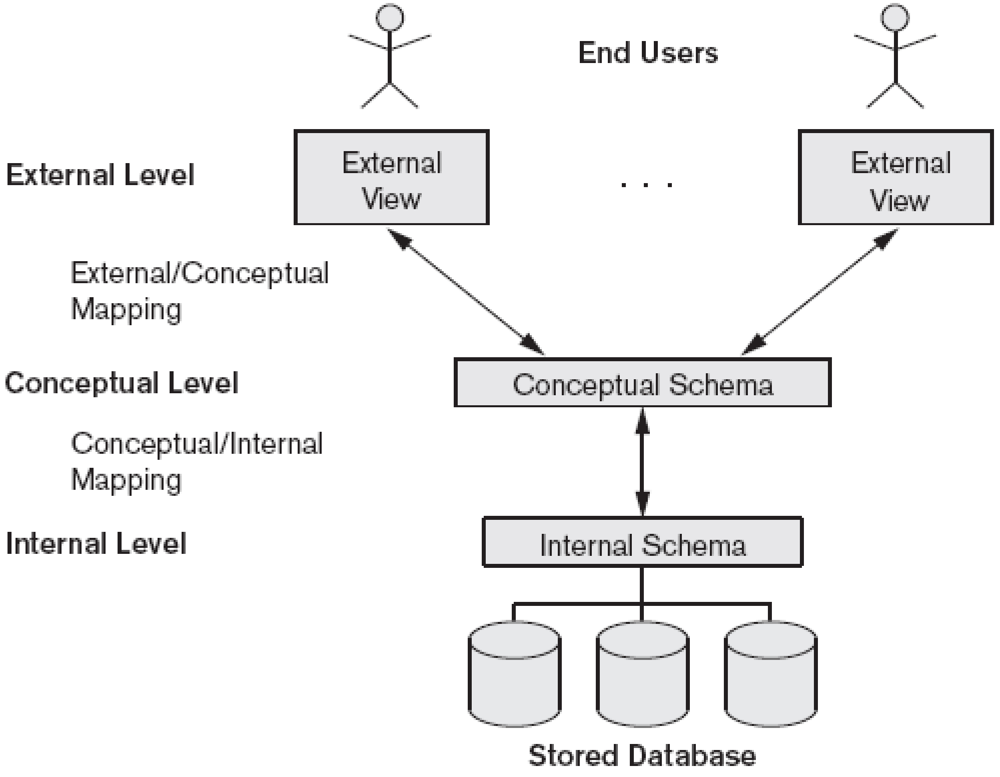

Figure 2.2
The three-schema architecture.

Data Independence

Capacity to change the schema at one level of a database system

Without having to change the schema at the next higher level

Types:

Logical

Physical

DBMS Languages

Data definition language (DDL)

- Defines both schemas

Storage definition language (SDL)

- Specifies the internal schema

View definition language (VDL)

- Specifies user views/mappings to conceptual schema

Data manipulation language (DML)

- Allows retrieval, insertion, deletion, modification

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DBMS Languages (cont'd.)

High-level or **nonprocedural** DML

- Can be used on its own to specify complex database operations concisely
- **Set-at-a-time** or **set-oriented**

Low-level or **procedural** DML

- Must be embedded in a general-purpose programming language
- **Record-at-a-time**

DBMS Interfaces

Menu-based interfaces for Web clients or browsing

Forms-based interfaces

Graphical user interfaces

Natural language interfaces

Speech input and output

Interfaces for parametric users

Interfaces for the DBA

The Database System Environment

DBMS component modules

Buffer management

Stored data manager

DDL compiler

Interactive query interface

- **Query compiler**
- **Query optimizer**

Precompiler

The Database System Environment (cont'd.)

DBMS component modules

- **Runtime database processor**
- **System catalog**
- **Concurrency control system**
- **Backup and recovery system**

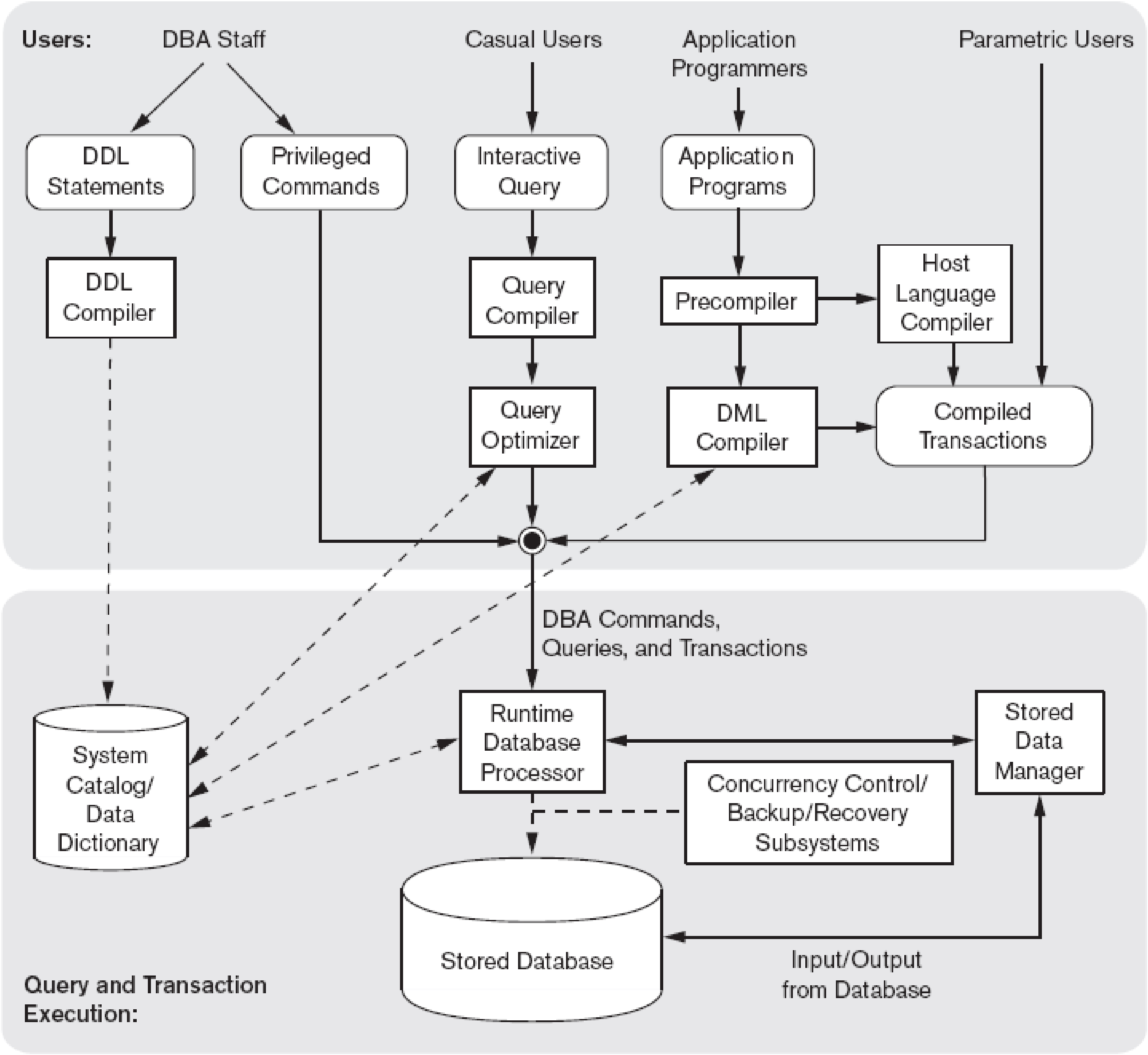

Figure 2.3
Component modules of a DBMS and their interactions.

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Database System Utilities

Loading

Load existing data files

Backup

Creates a backup copy of the database

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Database System Utilities (cont'd.)

Database storage reorganization

Reorganize a set of database files into different file organizations

Performance monitoring

Monitors database usage and provides statistics to the DBA

Tools, Application Environments, and Communications Facilities

- CASE Tools
- **Data dictionary (data repository) system**
  - Stores design decisions, usage standards, application program descriptions, and user information
- **Application development environments**
- **Communications software**

Centralized and Client/Server Architectures for DBMSs

Centralized DBMSs Architecture

All DBMS functionality, application program execution, and user interface processing carried out on one machine

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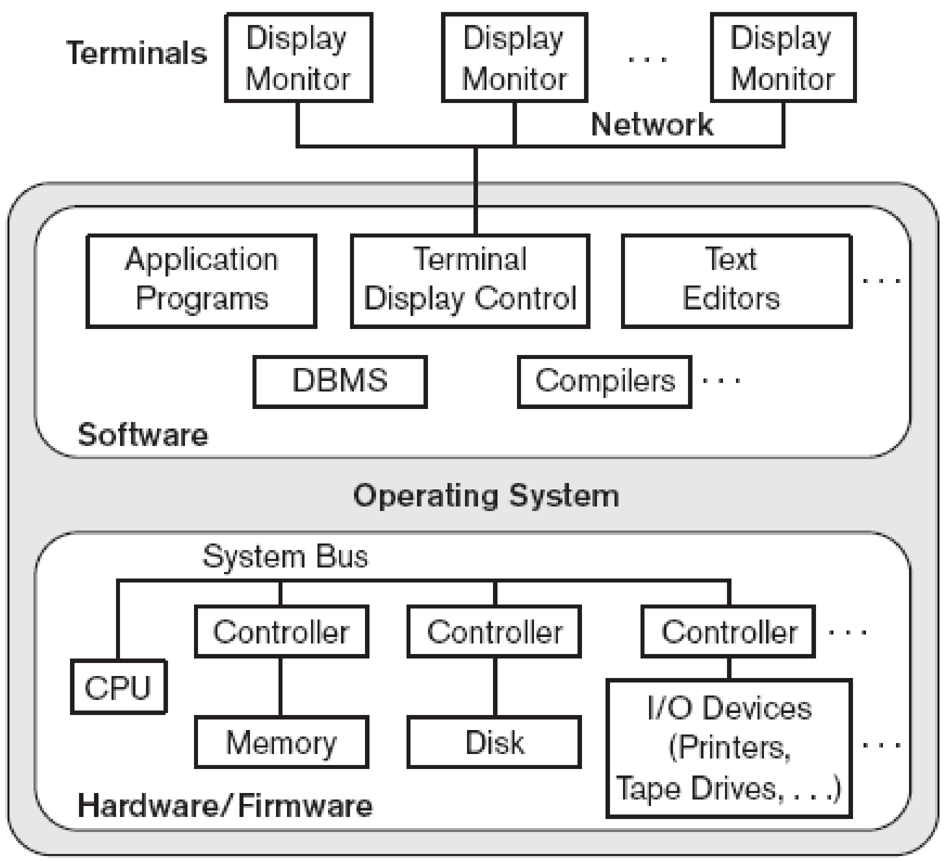

Figure 2.4
A physical centralized architecture.

Basic Client/Server Architectures

- **Servers** with specific functionalities
  - **File server**
    - Maintains the files of the client machines.
  - **Printer server**
    - Connected to various printers; all print requests by the clients are forwarded to this machine
  - **Web servers** or **e-mail servers**

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Basic Client/Server Architectures (cont'd.)

Client machines

Provide user with:

- Appropriate interfaces to utilize these servers
- Local processing power to run local applications

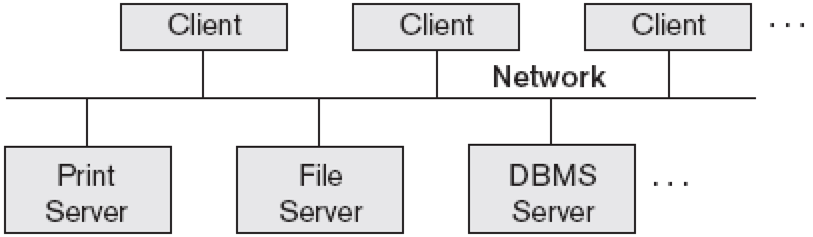

Figure 2.5
Logical two-tier client/server architecture.

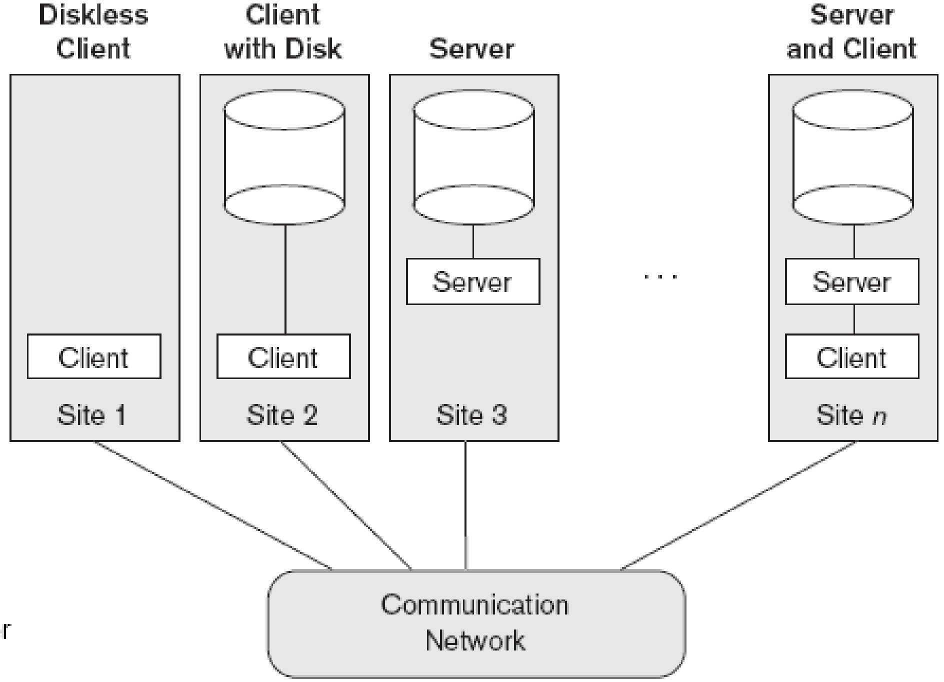

Figure 2.6
Physical two-tier client/server architecture.

Basic Client/Server Architectures (cont'd.)

Client

User machine that provides user interface capabilities and local processing

Server

System containing both hardware and software

Provides services to the client machines

- Such as file access, printing, archiving, or database access

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Two-Tier Client/Server Architectures for DBMSs

- Server handles
  - Query and transaction functionality related to SQL processing
- Client handles
  - User interface programs and application programs

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Two-Tier Client/Server Architectures (cont'd.)

Open Database Connectivity (ODBC)

Provides application programming interface (API)

Allows client-side programs to call the DBMS

- Both client and server machines must have the necessary software installed

JDBC

Allows Java client programs to access one or more DBMSs through a standard interface

Three-Tier and n-Tier Architectures for Web Applications

Application server or **Web server**

- Adds intermediate layer between client and the database server
- Runs application programs and stores business rules

N-tier

- Divide the layers between the user and the stored data further into finer components

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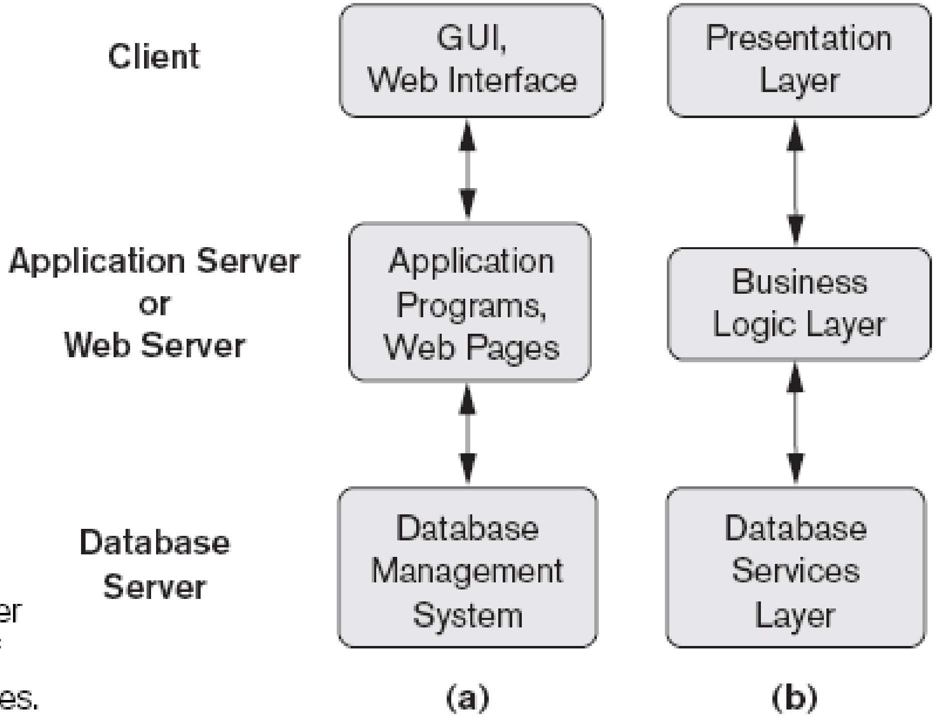

Figure 2.7
Logical three-tier client/server architecture, with a couple of commonly used nomenclatures.

Classification of Database Management Systems

Data model

- **Relational**
- **Object**
- **Hierarchical** and **network** (legacy)
- **Native XML DBMS**

Number of users

- **Single-user**
- **Multiuser**

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Classification of Database Management Systems (cont'd.)

Number of sites

- **Centralized**
- **Distributed**
  - **Homogeneous**
  - **Heterogeneous**

Cost

- Open source
- Different types of licensing

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Classification of Database Management Systems (cont'd.)

- **Types of access path options**
- **General** or **special-purpose**

Classification of Database Management Systems (cont'd.)

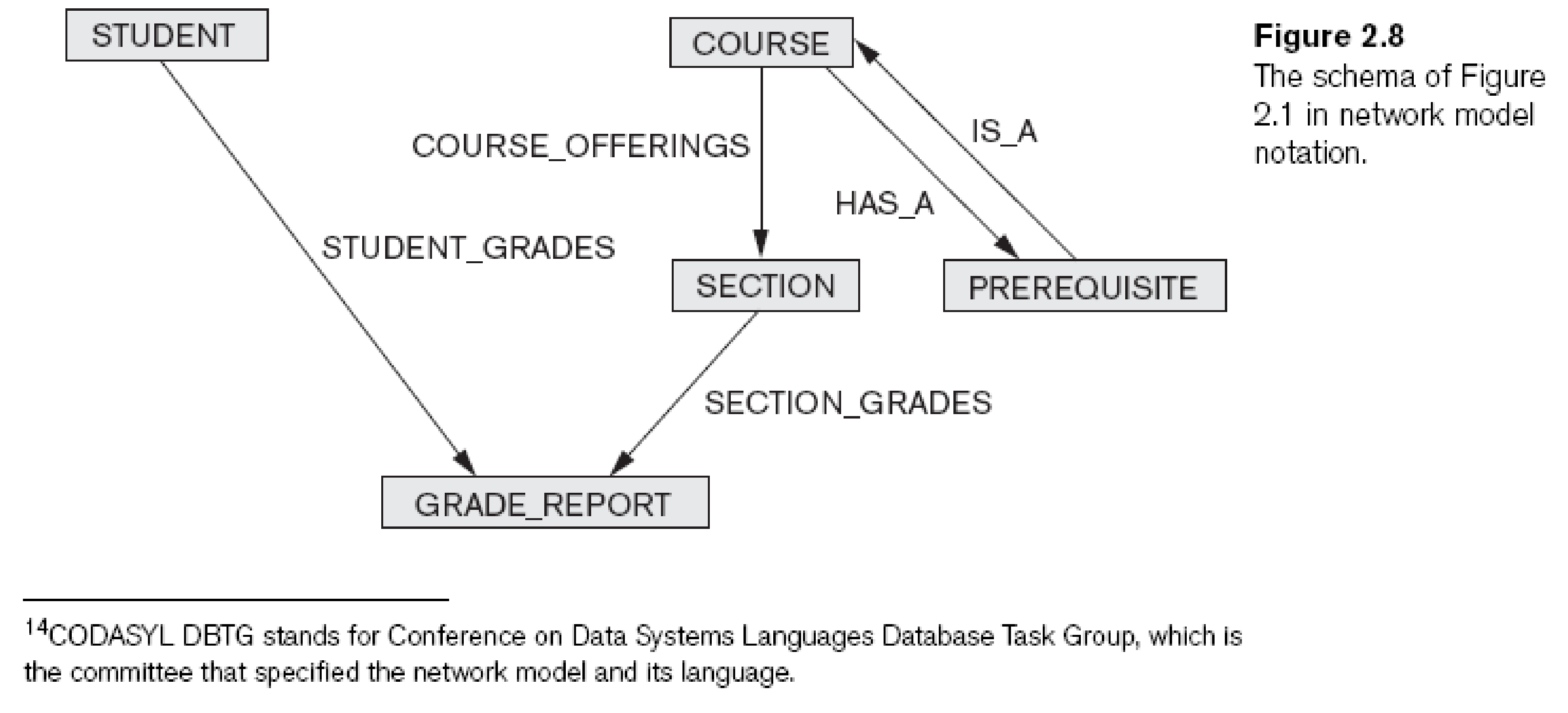

Figure 2.8
The schema of Figure 2.1 in network model notation.

[14] CODASYL DBTG stands for Conference on Data Systems Languages Database Task Group, which is the committee that specified the network model and its language.

Summary

Concepts used in database systems

Main categories of data models

Types of languages supported by DMBSs

Interfaces provided by the DBMS

DBMS classification criteria:

Data model, number of users, number of sties, access paths, cost

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