



Chapter 2: Concepts and Architecture

CS-6360 Database Systems

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Chapter 2 Outline



- 2.1 Data Models, Schemas, and Instances
- 2.2 Three-Schema Architecture and Data Independence
- 2.3 Database Languages and Interfaces
- 2.4 The Database System Environment
- 2.5 Centralized and Client/Server Architectures for DBMSs
- 2.6 Classification of Database Management Systems

2.1 Data Models, Schemas, and Instances

■ Data model

- One fundamental characteristic of the database approach is that it provides some level of **data abstraction**.
- Collection of concepts that describe the structure of a database
- **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

§2.1.1 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
 - Hides many details of data storage on disk, but can be implemented on a computer system directly

Categories of Data Models



- **Conceptual Types**
- **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
- **Semantic data model**
 - Semantic Web

- **Conceptual Features**
 - **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

Categories of Data Models



■ Physical

- 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

Schemas, Instances, and Database State



- In any data model, it is important to distinguish between the *description* of the database and the *database itself*

Schemas, Instances, and Database State



■ Database schema

- Description of a database

■ Schema diagram

- Displays selected aspects of schema

■ Schema construct

- Each object/instance in the schema (e.g. STUDENT or COURSE)

■ Database state or snapshot

- Data in database at a particular moment in time

Schemas, Instances, and Database State



Figure 2.1
Schema diagram for the
database in Figure 1.2.

STUDENT

Name	Student_number	Class	Major
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COURSE

Course_name	Course_number	Credit_hours	Department
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PREREQUISITE

Course_number	Prerequisite_number
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SECTION

Section_identifier	Course_number	Semester	Year	Instructor
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GRADE_REPORT

Student_number	Section_identifier	Grade
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⁷It 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



Figure 2.1

Schema diagram for the database in Figure 1.2.

Table Name
Relation Name

STUDENT

Name	Student_number	Class	Major
------	----------------	-------	-------

COURSE

Course_name	Course_number	Credit_hours	Department
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PREREQUISITE

Course_number	Prerequisite_number
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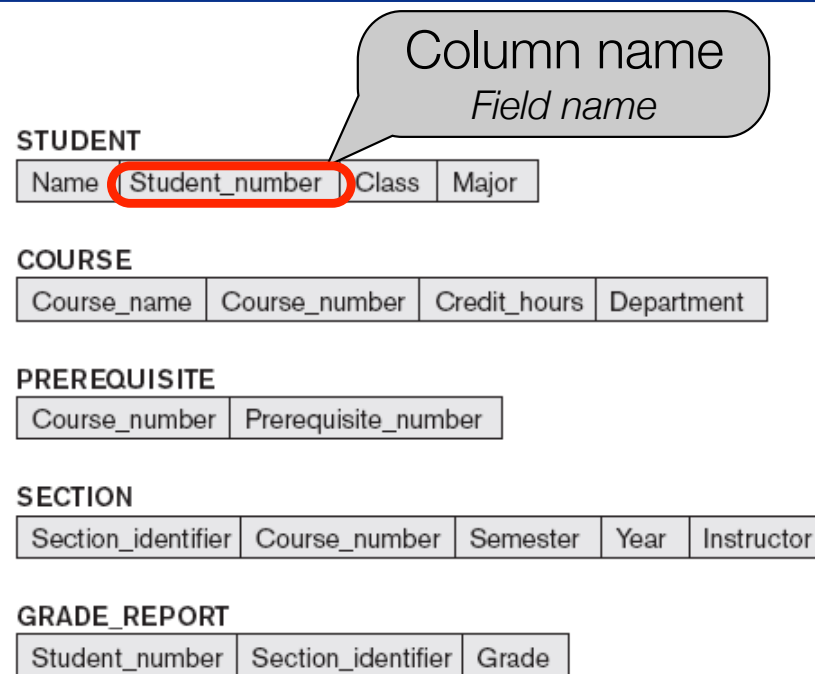
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Schemas, Instances, and Database State



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Schemas, Instances, and Database State



- **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
- **Schema evolution**
 - Changes applied to schema as application requirements change

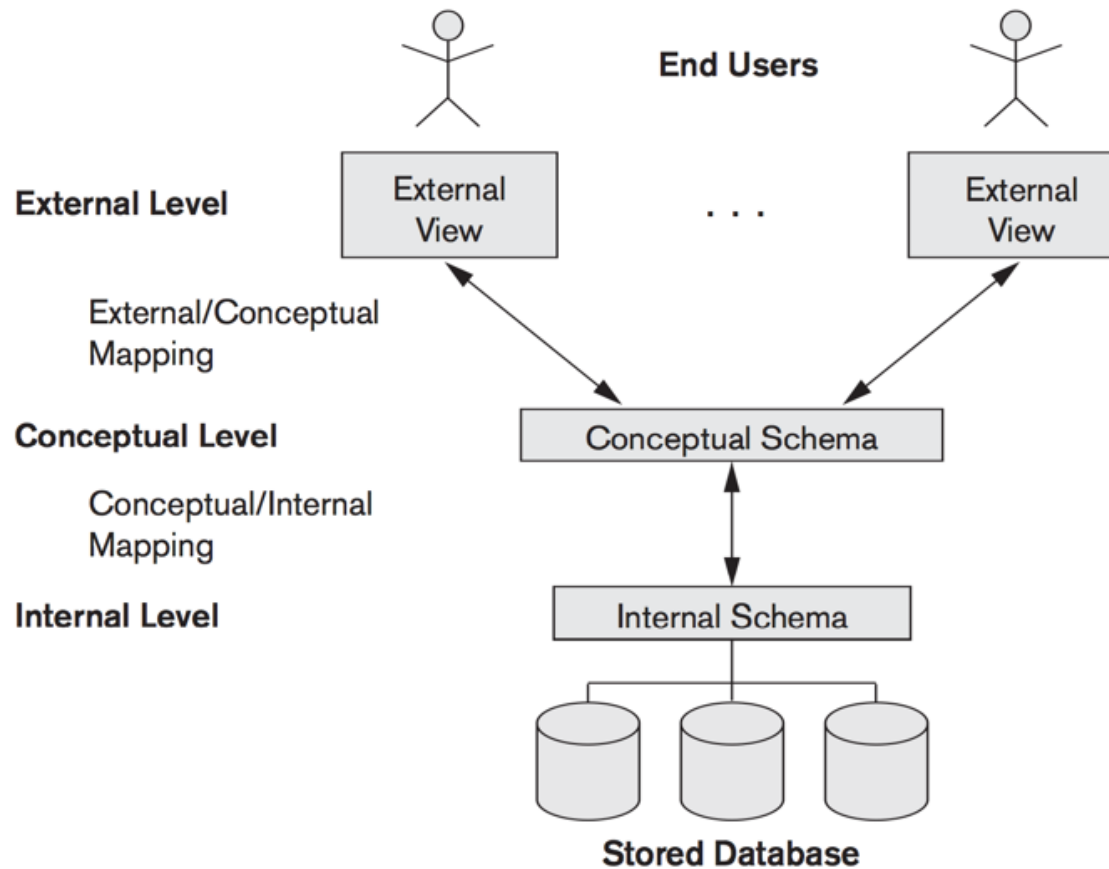
2.2 Three-Schema Architecture and Data Independence

Three-Schema Architecture and Data Independence

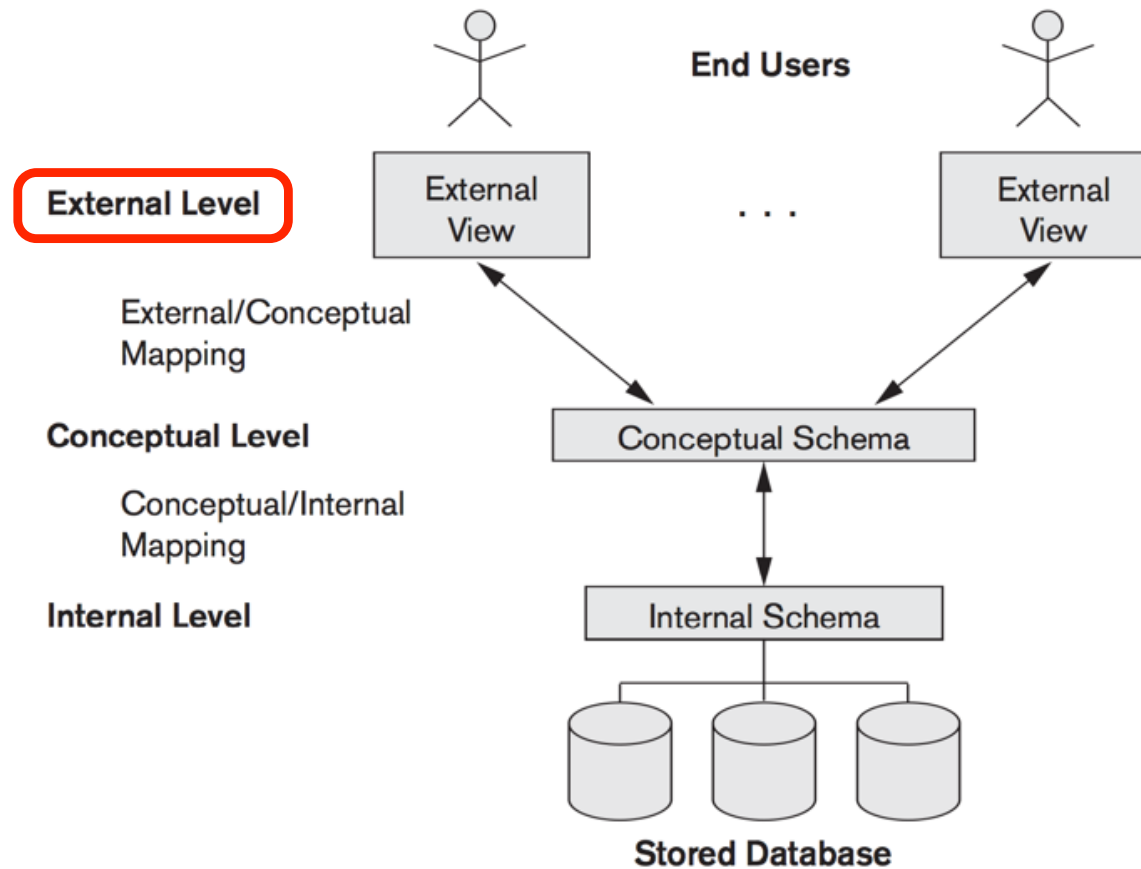


- **Internal level**
 - Describes physical storage structure of the database
- **Conceptual level**
 - Describes structure of the whole database for a community of users
- **External or view level**
 - Describes part of the database that a particular user group is interested in

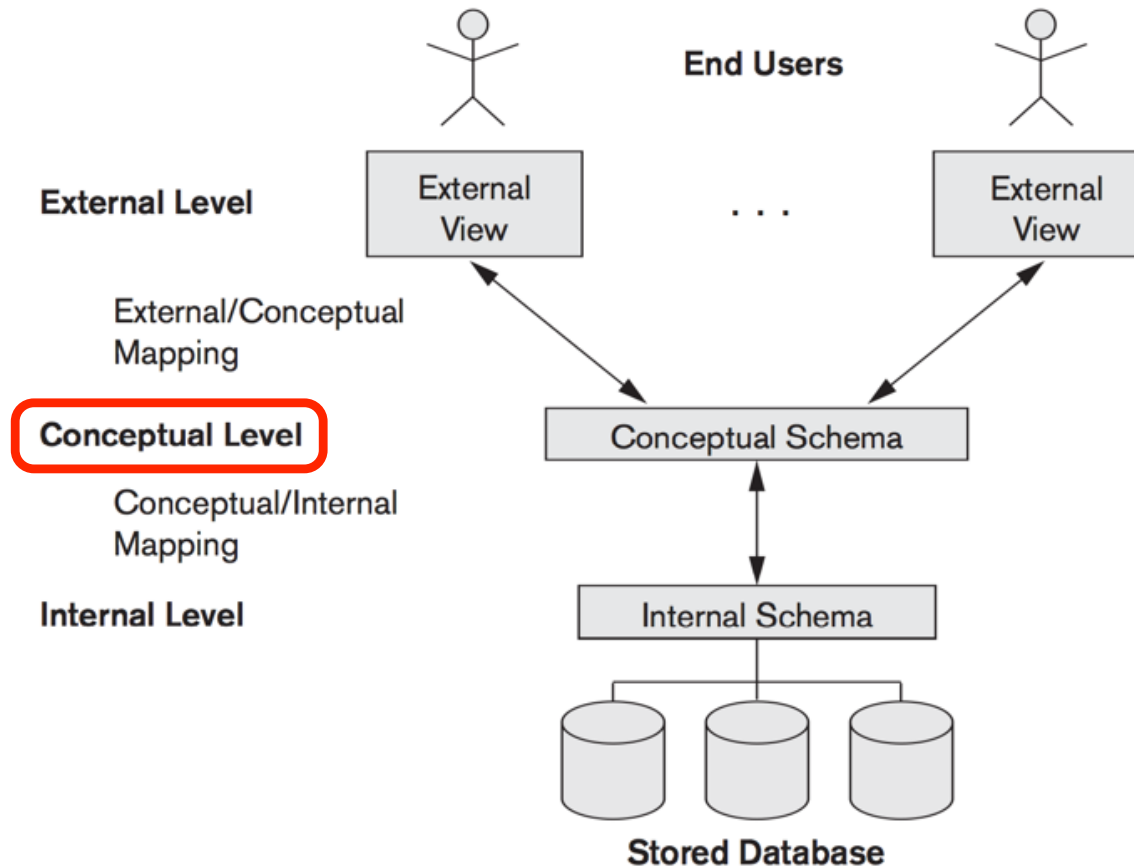
Three-Schema Architecture and Data Independence



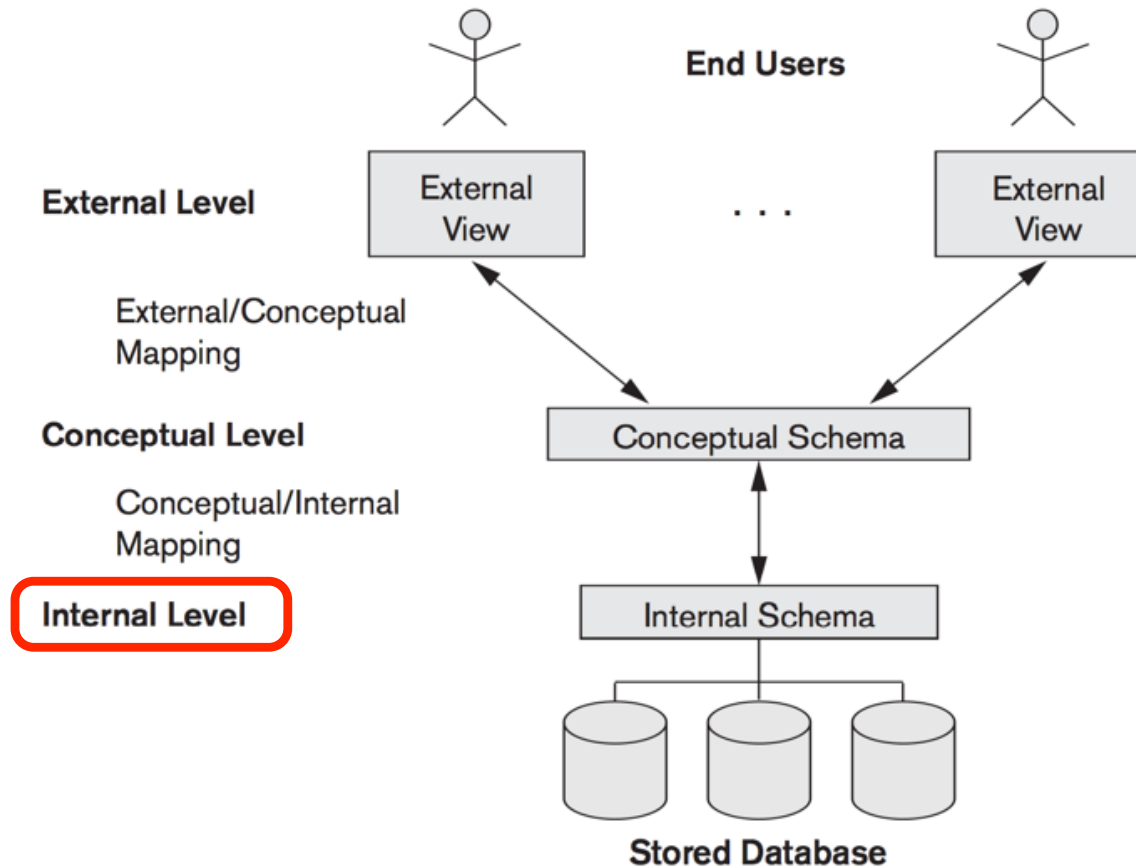
Three-Schema Architecture and Data Independence



Three-Schema Architecture and Data Independence



Three-Schema Architecture and Data Independence



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**
- For example, changing to a different DBMS or disk drive without having to change the schema.

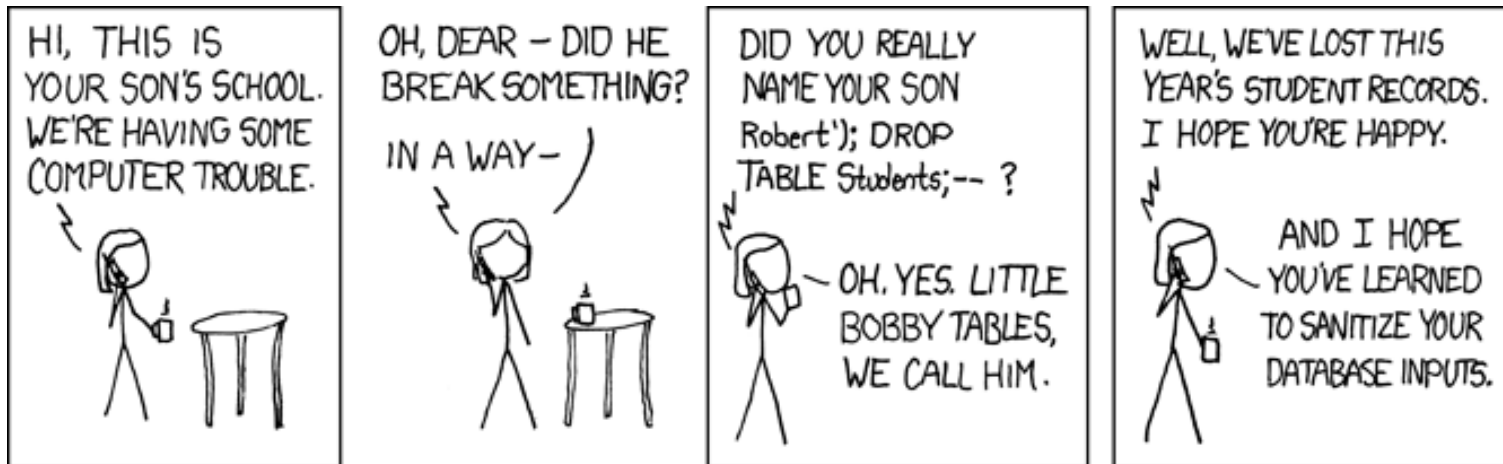
2.3 Database Languages and Interfaces

- **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

DBMS User Interfaces (UIs)



- Menu-based interfaces for Web clients or browsing
- Forms-based interfaces
- Graphical user interfaces (Like SSMS)
- Natural language interfaces
- Speech input and output
- Interfaces for parametric users
- Interfaces for the DBA





2.5 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
- This was the mainframe model, with dumb terminals. It is still widely used.

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**

Basic Client/Server Architectures



- **Client machines**
 - Provide user with:
 - Appropriate interfaces to utilize these servers
 - Local processing power to run local applications
- **Server**
 - System containing both hardware and software
 - Provides services to the client machines
 - Such as file access, printing, archiving, or database access

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

Two-Tier Client/Server Architectures for DBMSs



- 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
- Java Database Connectivity (**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

Service Oriented Architecture



- Many different components of a system are services
- These may reside in the same machine or different machines.
- Database service, various business process services, calendar service, etc.

Three-Tier Architecture

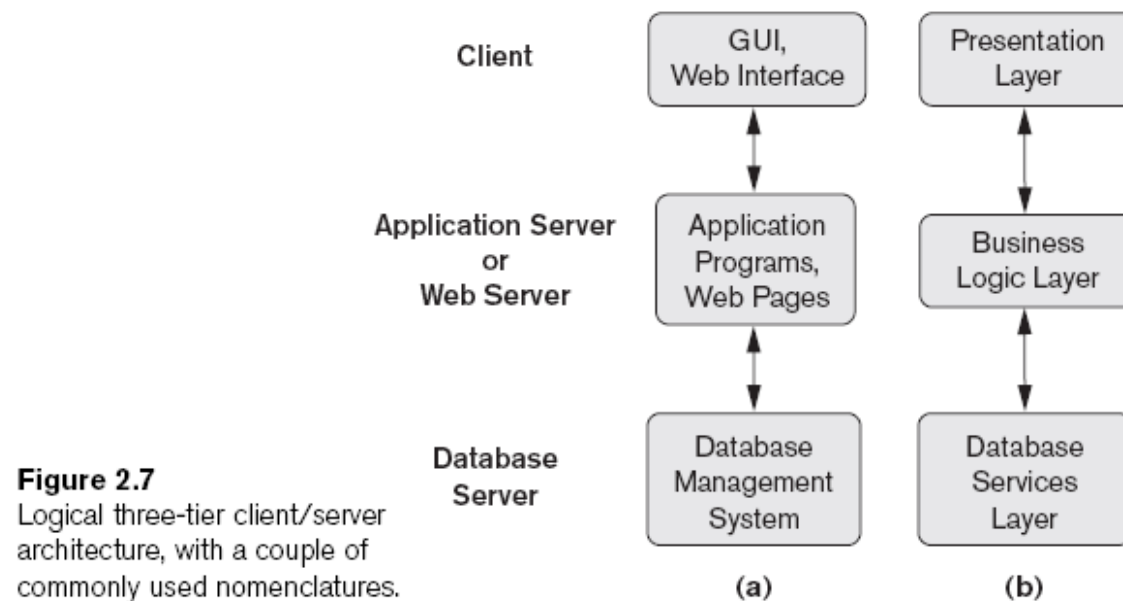


Figure 2.7
Logical three-tier client/server architecture, with a couple of commonly used nomenclatures.

2.6 Classification of Database Management Systems

Classification of Database Management Systems



- Data model
 - Relational
 - Object
 - Hierarchical and network (legacy)
 - Native XML DBMS
- Number of users
 - Single-user
 - Multiuser

Classification of Database Management Systems



- **Number of sites**
 - **Centralized**
 - **Distributed**
 - **Homogeneous**
 - **Heterogeneous**
- **Cost**
 - Open source
 - Different types of licensing

Classification of Database Management Systems



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

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