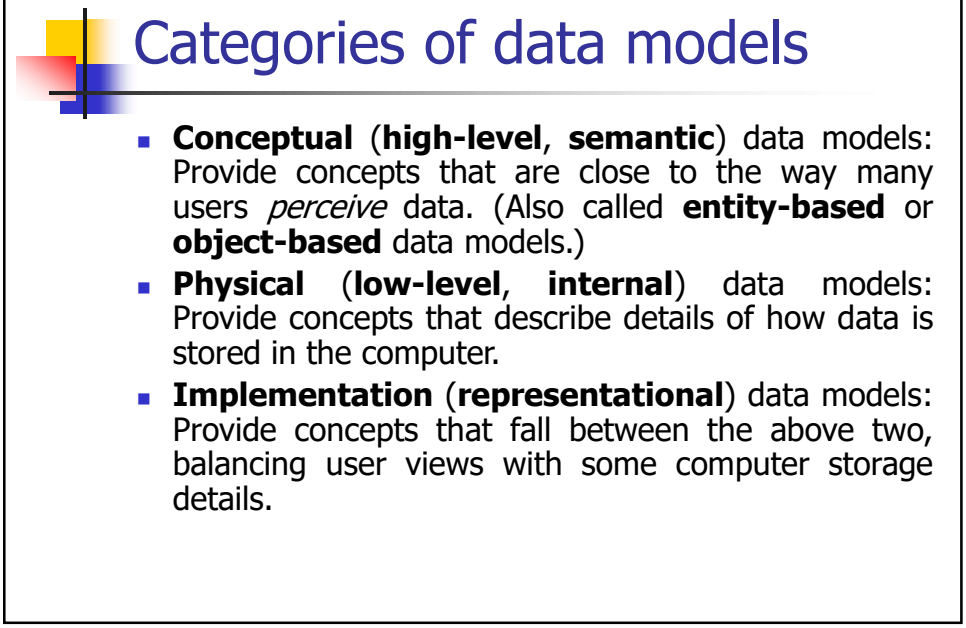
Database System Concepts and Architecture

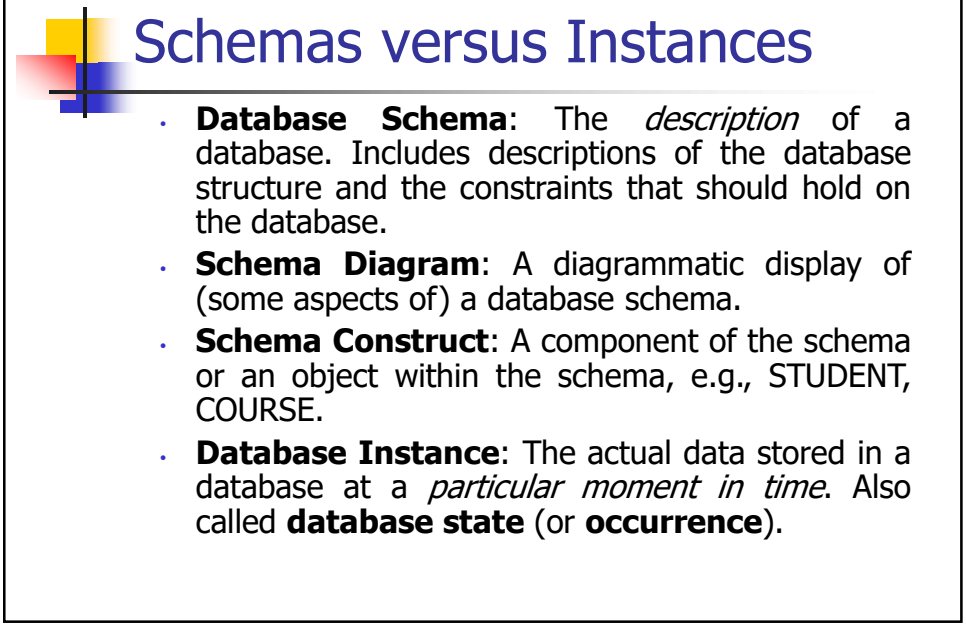
Data Models

- **Data Model**: A set of concepts to describe the *structure* of a database, and certain *constraints* that the database should obey.
- **Data Model Operations**: Operations for specifying database retrievals and updates by referring to the concepts of the data model. Operations on the data model may include *basic operations* and *user-defined operations*.



Categories of data models

- **Conceptual** (**high-level**, **semantic**) data models: Provide concepts that are close to the way many users *perceive* data. (Also called **entity-based** or **object-based** data models.)
- **Physical** (**low-level**, **internal**) data models: Provide concepts that describe details of how data is stored in the computer.
- **Implementation** (**representational**) data models: Provide concepts that fall between the above two, balancing user views with some computer storage details.



Schemas versus Instances

- **Database Schema**: The *description* of a database. Includes descriptions of the database structure and the constraints that should hold on the database.
- **Schema Diagram**: A diagrammatic display of (some aspects of) a database schema.
- **Schema Construct**: A component of the schema or an object within the schema, e.g., STUDENT, COURSE.
- **Database Instance**: The actual data stored in a database at a *particular moment in time*. Also called **database state** (or **occurrence**).

Schema diagram for the database discussed earlier

STUDENT

Name	StudentNumber	Class	Major

COURSE

CourseName	CourseNumber	CreditHours	Department

PREREQUISITE

CourseNumber	PrerequisiteNumber

SECTION

SectionIdentifier	CourseNumber	Semester	Year	Instructor

GRADE_REPORT

StudentNumber	SectionIdentifier	Grade

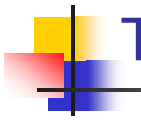
Database Schema Vs. Database State

- **Database State:** Refers to the content of a database at a moment in time.
- **Initial Database State:** Refers to the database when it is loaded
- **Valid State:** A state that satisfies the structure and constraints of the database.
- **Distinction**
  - The **database schema** changes *very infrequently*. The **database state** changes *every time the database is updated.*
  - **Schema** is also called **intension**, whereas **state** is called **extension**.

Example of a Database State

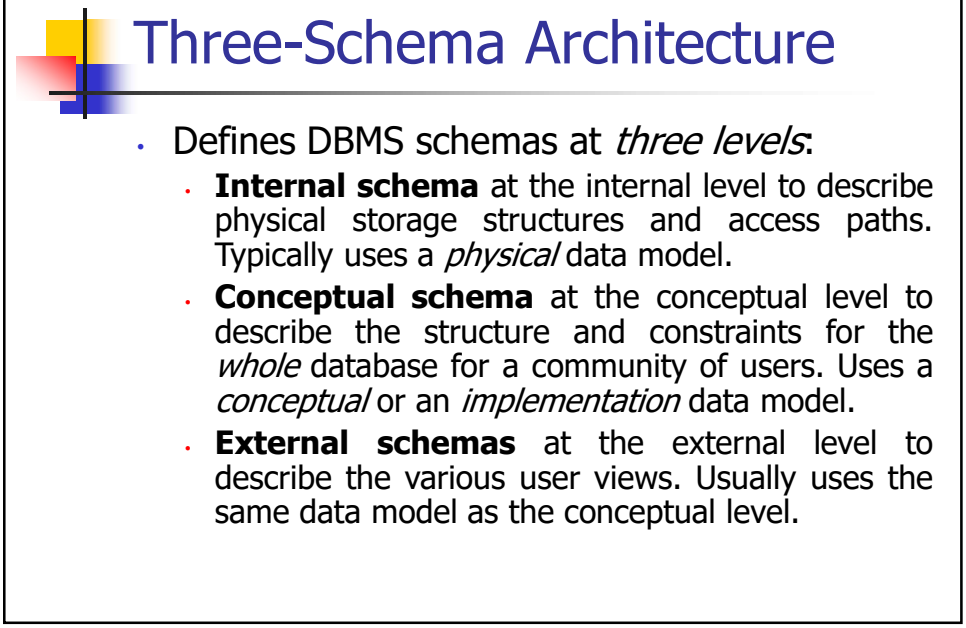
COURSE

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



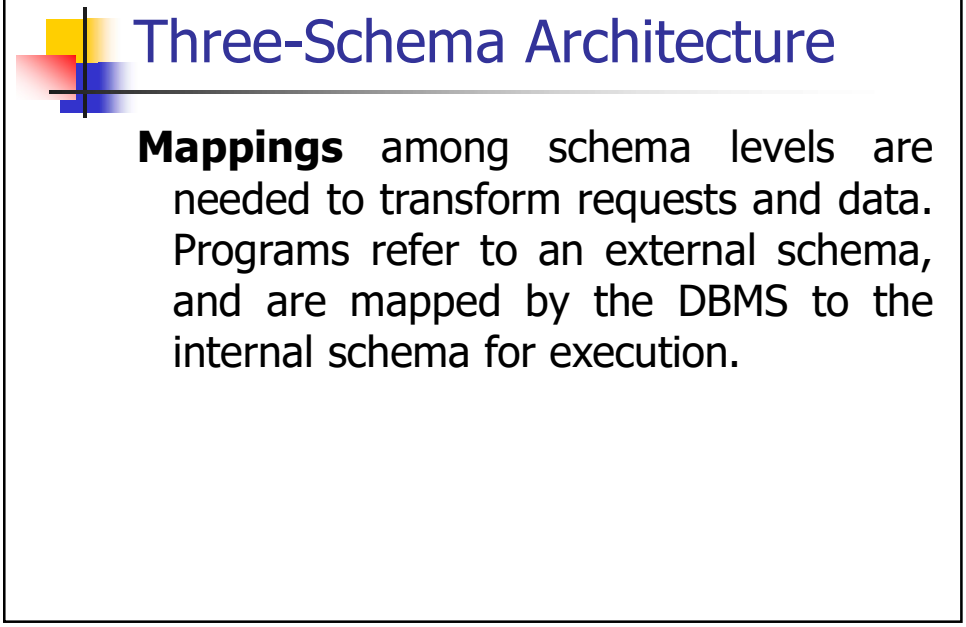
Three-Schema Architecture

- Proposed to support DBMS characteristics of:
  - **Program-data independence**.
  - Support of **multiple views** of the data.



Three-Schema Architecture

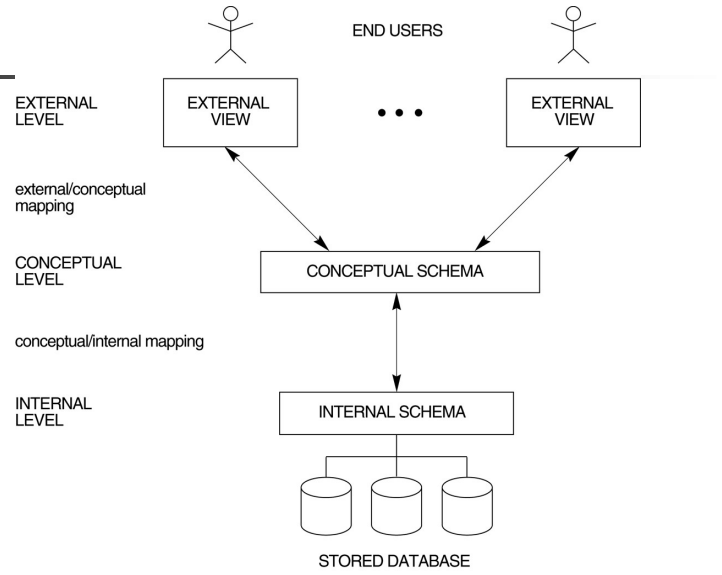
- Defines DBMS schemas at *three levels*:
  - **Internal schema** at the internal level to describe physical storage structures and access paths. Typically uses a *physical* data model.
  - **Conceptual schema** at the conceptual level to describe the structure and constraints for the *whole* database for a community of users. Uses a *conceptual* or an *implementation* data model.
  - **External schemas** at the external level to describe the various user views. Usually uses the same data model as the conceptual level.



Three-Schema Architecture

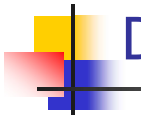
Mappings among schema levels are needed to transform requests and data. Programs refer to an external schema, and are mapped by the DBMS to the internal schema for execution.

The three-schema architecture.



Data Independence

- **Logical Data Independence**: The capacity to change the conceptual schema without having to change the external schemas and their application programs.
- **Physical Data Independence**: The capacity to change the internal schema without having to change the conceptual schema.

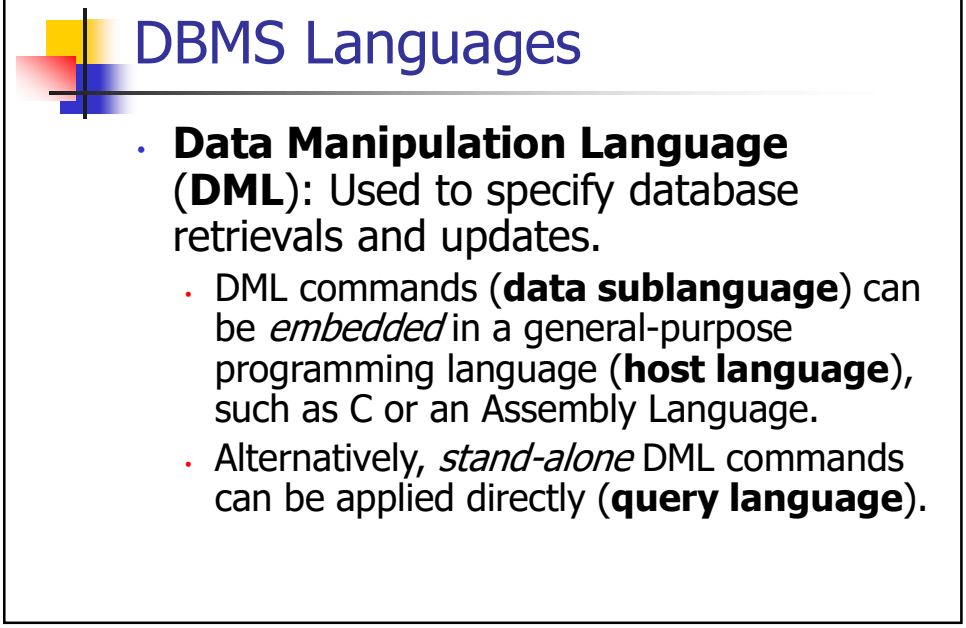


Data Independence

When a schema at a lower level is changed, only the **mappings** between this schema and higher-level schemas need to be changed in a DBMS that fully supports data independence. The higher-level schemas themselves are *unchanged*. Hence, the application programs need not be changed since they refer to the external schemas.

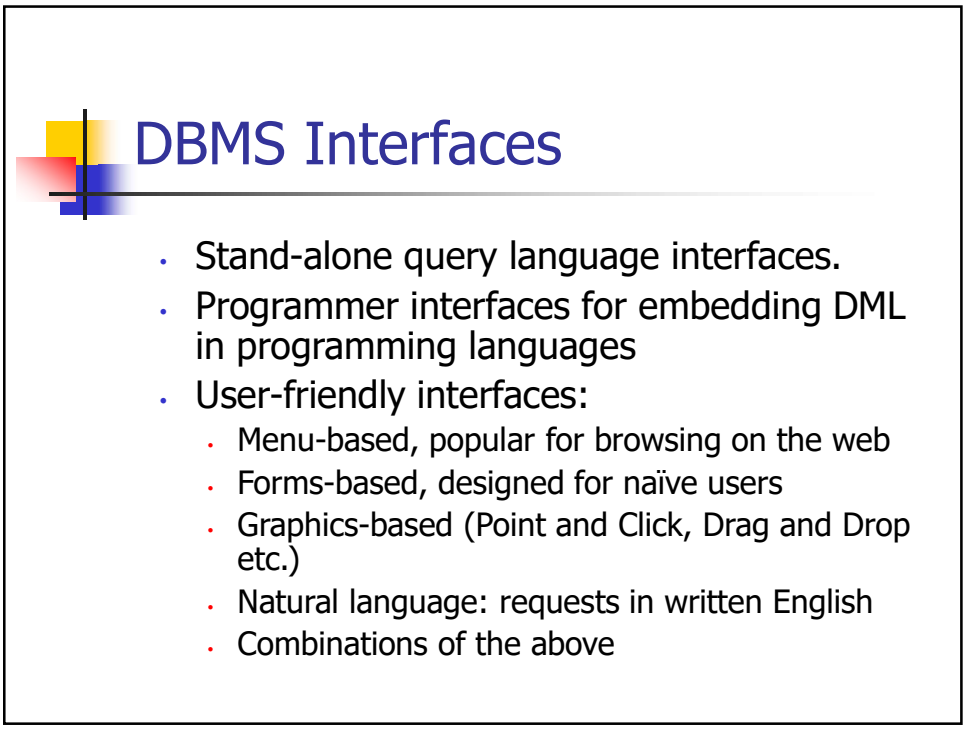
DBMS Languages

- **Data Definition Language** (**DDL**): Used by the DBA and database designers to specify the *conceptual schema* of a database. In many DBMSs, the DDL is also used to define internal and external schemas (views).



DBMS Languages

- **Data Manipulation Language** (**DML**): Used to specify database retrievals and updates.
  - DML commands (**data sublanguage**) can be *embedded* in a general-purpose programming language (**host language**), such as C or an Assembly Language.
  - Alternatively, *stand-alone* DML commands can be applied directly (**query language**).



DBMS Interfaces

- Stand-alone query language interfaces.
- Programmer interfaces for embedding DML in programming languages
- User-friendly interfaces:
  - Menu-based, popular for browsing on the web
  - Forms-based, designed for naïve users
  - Graphics-based (Point and Click, Drag and Drop etc.)
  - Natural language: requests in written English
  - Combinations of the above

Centralized and Client-Server Architectures

- **Centralized DBMS:** combines everything into single system including- DBMS software, hardware, application programs and user interface processing software.

Basic Client-Server Architectures

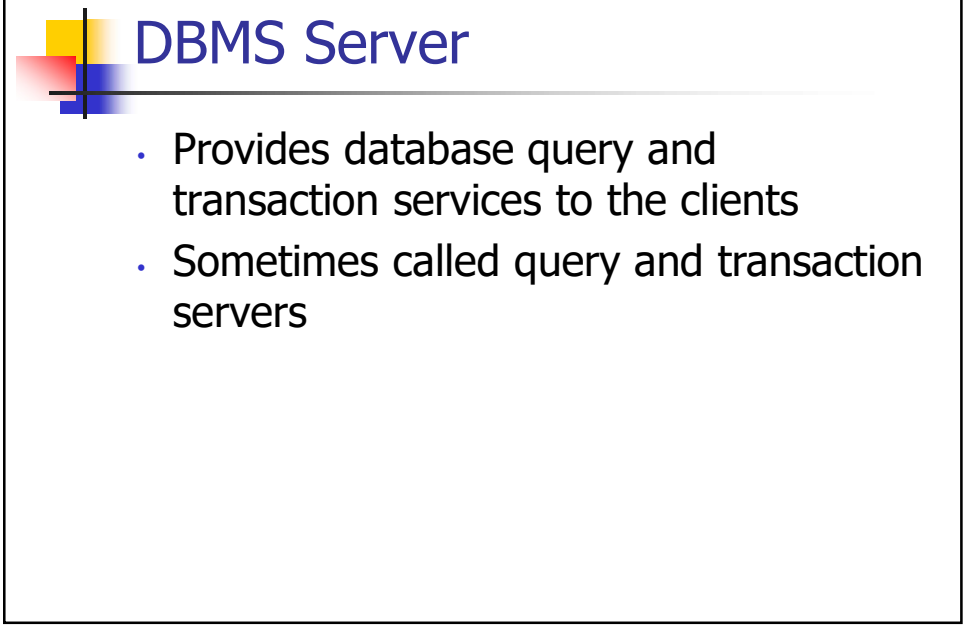
- **Specialized Servers with Specialized functions**
- **Clients**
- **DBMS Server**

Specialized Servers with Specialized functions:

- File Servers
- Web Servers
- E-mail Servers

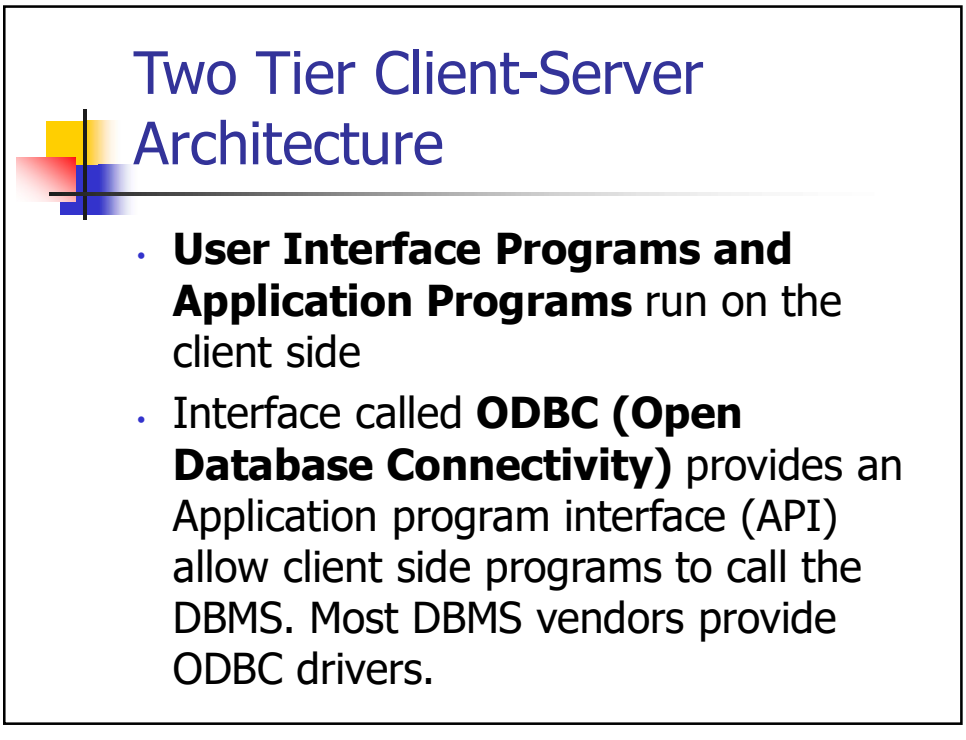
Clients:

- Provide appropriate interfaces and a client-version of the system to access and utilize the server resources.
- Clients maybe diskless machines or PCs or Workstations with disks with only the client software installed.
- Connected to the servers via some form of a network.
  (LAN: local area network, wireless network, etc.)



DBMS Server

- Provides database query and transaction services to the clients
- Sometimes called query and transaction servers



Two Tier Client-Server Architecture

- **User Interface Programs and Application Programs** run on the client side
- Interface called **ODBC (Open Database Connectivity)** provides an Application program interface (API) allow client side programs to call the DBMS. Most DBMS vendors provide ODBC drivers.

Three Tier Client-Server Architecture

- Common for **Web applications**
- Intermediate Layer called **Application Server** or **Web Server:**
  - stores the web connectivity software and **the rules and business logic (constraints)** part of the application used to access the right amount of data from the database server
  - acts like a conduit for sending partially processed data between the database server and the client.
- **Additional Features- Security:**
  - encrypt the data at the server before transmission
  - decrypt data at the client

Classification of DBMSs

- **Based on the data model used**:
  - Relational, Network, Hierarchical.
  - Object-oriented, Object-relational.
- **Other classifications:**
  - Single-user (typically used with micro- computers) vs. multi-user (most DBMSs).
  - Centralized (uses a single computer with one database) vs. distributed (uses multiple computers, multiple databases)

Acknowledgement

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- Ramez Elmasri and Shamkant B. Navathe, *Fundamentals of Database Systems,* Pearson Education.

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