Chapter 1
Introduction : Database and DBMS

Types of Databases and Database Applications

- Numeric and Textual Databases
- Multimedia Databases
- Geographic Information Systems (GIS)
- Data Warehouses
- Real-time and Active Databases

(A number of these databases and applications are described later through this course.)

Basic Definitions

- **Database**: A collection of related data.
- **Data**: Known facts that can be recorded and have an implicit meaning.
- **Information**: Processed data (i.e. data under consideration). Event makes data into information. It is user specific.
- **Mini-world**: Some part of the real world about which data is stored in a database. For example, student grades and transcripts at a university.
- **Database Management System (DBMS)**: A software package/ system to facilitate the creation and maintenance of a computerized database.
- **Database System**: The DBMS software together with the data itself. Sometimes, the applications are also included.

Typical DBMS Functionality

- ✓ Define a database : in terms of data types, structures and constraints
- ✓ Construct or Load the Database on a secondary storage medium
- ✓ Manipulating the database : querying, generating reports, insertions, deletions and modifications to its content
- ✓ Concurrent Processing and Sharing by a set of users and programs – yet, keeping all data valid and consistent

Other features:

- ✓ Protection or Security measures to prevent unauthorized access
- ✓ "Active" processing to take internal actions on data
- ✓ Presentation and Visualization of data

Example of a Database (with a Conceptual Data Model)

- **Mini-world for the example**: Part of a UNIVERSITY environment.
- **Some mini-world *entities***:
  - ✓ STUDENTs
  - ✓ COURSEs
  - ✓ SECTIONs (of COURSEs)
  - ✓ (academic) DEPARTMENTs
  - ✓ INSTRUCTORs

Note: The above could be expressed in the ENTITY RELATIONSHIP data model.

Example of a Database (with a Conceptual Data Model)

Some mini-world *relationships*:

- ✓ SECTIONs *are of* specific COURSEs
- ✓ STUDENTs *take* SECTIONs
- ✓ COURSEs *have* prerequisite COURSEs
- ✓ INSTRUCTORs *teach* SECTIONs
- ✓ COURSEs *are offered by* DEPARTMENTs
- ✓ STUDENTs *major in* DEPARTMENTs

Note: The above could be expressed in the *ENTITY-RELATIONSHIP* data model.

Main Characteristics of the Database Approach

- **Self-describing nature of a database system**: A DBMS **catalog** stores the *description* of the database. The description is called **meta-data**). This allows the DBMS software to work with different databases.
- **Insulation between programs and data**: Called **program-data independence**. Allows changing data storage structures and operations without having to change the DBMS access programs.
- **Data Abstraction**: A **data model** is used to hide storage details and present the users with a *conceptual view* of the database.
- **Support of multiple views of the data**: Each user may see a different view of the database, which describes *only* the data of interest to that user.
- **Sharing of data and multi-user transaction processing**: allowing a set of concurrent users to retrieve and to update the database. Concurrency control within the DBMS guarantees that each **transaction** is correctly executed or completely aborted. OLTP (Online Transaction Processing) is a major part of database applications.

Database Users

Users may be divided into those who actually use and control the content (called "Actors on the Scene") and those who enable the database to be developed and the DBMS software to be designed and implemented (called "Workers Behind the Scene").

Actors on the scene

- **Database administrators:** responsible for authorizing access to the database, for coordinating and monitoring its use, acquiring software, and hardware resources, controlling its use and monitoring efficiency of operations.
- **Database Designers:** responsible to define the content, the structure, the constraints, and functions or transactions against the database. They must communicate with the end-users and understand their needs.
- **End-users:** they use the data for queries, reports and some of them actually update the database content.

Categories of End-users

- ✓ **Casual:** access database occasionally when needed
- ✓ **Naïve or Parametric:** they make up a large section of the end-user population. They use previously well-defined functions in the form of "canned transactions" against the database. Examples are bank-tellers or reservation clerks who do this activity for an entire shift of operations.
- ✓ **Sophisticated:** these include business analysts, scientists, engineers, others thoroughly familiar with the system capabilities. Many use tools in the form of software packages that work closely with the stored database.
- ✓ **Stand-alone:** mostly maintain personal databases using ready-to-use packaged applications. An example is a tax program user that creates his/her own internal database.

Advantages of Using the Database Approach

- Controlling redundancy in data storage and in development and maintenance efforts.
- Sharing of data among multiple users.
- Restricting unauthorized access to data.
- Providing persistent storage for program Objects (in Object-oriented DBMS)
- Providing Storage Structures for efficient Query Processing
- Providing backup and recovery services.
- Providing multiple interfaces to different classes of users.
- Representing complex relationships among data.
- Enforcing integrity constraints on the database.
- Drawing Inferences and Actions using

Additional Implications of Using the Database Approach

- Potential for enforcing standards: this is very crucial for the success of database applications in large organizations Standards refer to data item names, display formats, screens, report structures, meta-data (description of data) etc.
- Reduced application development time: incremental time to add each new application is reduced.
- Flexibility to change data structures: database structure may evolve as new requirements are defined.
- Availability of up-to-date information – very important for on-line transaction systems such as airline, hotel, car reservations.
- Economies of scale: by consolidating data and applications across departments wasteful overlap of resources and personnel can be avoided.

Historical Development of Database Technology (*introduction*)

- **Early Database Applications**: The Hierarchical and Network Models were introduced in mid 1960's and dominated during the seventies. A bulk of the worldwide database processing still occurs using these models.
- **Relational Model based Systems**: The model that was originally introduced in 1970 was heavily researched and experimented with in IBM and the universities. Relational DBMS Products emerged in the 1980's.
- **Object-oriented applications**: OODBMSs were introduced in late 1980's and early 1990's to cater to the need of complex data processing in CAD and other applications. Their use has not taken off much.
- **Data on the Web and E-commerce Applications**: Web contains data in HTML (Hypertext markup language) with links among pages. This has given rise to a new set of applications and E-commerce is using new standards like XML (eXtended MarkupLanguage).

Extending Database Capabilities

New functionality is being added to DBMSs in the following areas:

- Scientific Applications
- Image Storage and Management
- Audio and Video data management
- Data Mining
- Spatial data management
- Time Series and Historical Data Management

The above gives rise to new research and development in incorporating new data types, complex data structures, new operations and storage and indexing schemes in database systems.

When not to use a DBMS

- **Main inhibitors (costs) of using a DBMS**:
  - High initial investment and possible need for additional hardware.
  - Overhead for providing generality, security, concurrency control, recovery, and integrity functions.
- **When a DBMS may be unnecessary:**
  - If the database and applications are simple, well defined, and not expected to change.
  - If there are stringent real-time requirements that may not be met because of DBMS overhead.
  - If access to data by multiple users is not required.
- **When no DBMS may suffice:**
  - If the database system is not able to handle the complexity of data because of modeling limitations
  - If the database users need special operations not supported by the DBMS.

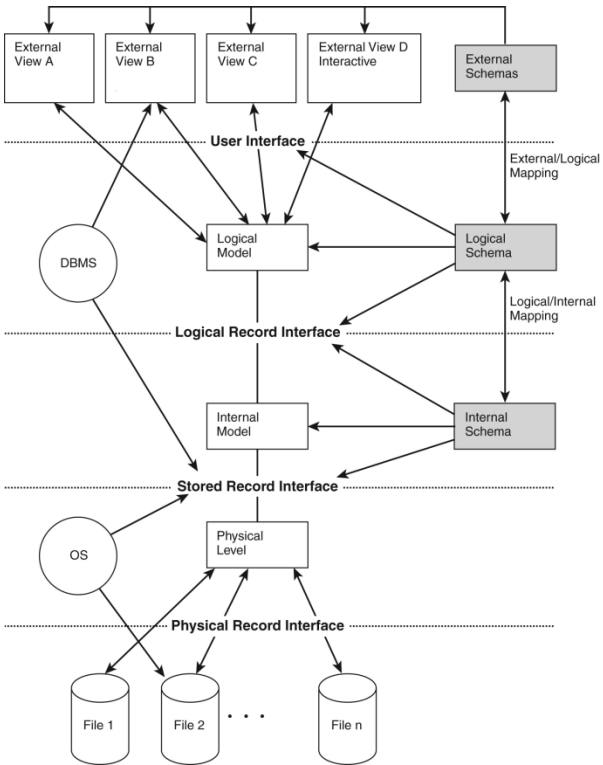
Examples of DBMS:
Oracle, Ingress, Sybase, DB2, Access, MySQL, MS Sql Server, FoxPro……

Three Level Database Architecture

Data are actually stored as bits, or numbers and strings, but it is difficult to work with data at this level.

It is necessary to view data at different levels of abstraction.

The DBMS management architecture can be classified as three level schema architecture as given below:



- physical,
- conceptual, and
- external.

Physical Data Level

The **physical schema** describes details of how data is stored: files, indices, etc. on the random access disk system. It also typically describes the record layout of files and type of files (hash, b-tree, flat).

Early applications worked at this level - explicitly dealt with details. E.g., minimizing physical distances between related data and organizing the data structures within the file (blocked records, linked lists of blocks, etc.)

Problem:

- Routines are hardcoded to deal with physical representation.
- Changes to data structures are difficult to make.
- Application code becomes complex since it must deal with details.
- Rapid implementation of new features very difficult.

Conceptual Data Level

Also referred to as the Logical level

Hides details of the physical level.

- In the relational model, the conceptual schema presents data as a set of tables.

The DBMS maps data access between the conceptual to physical schemas automatically.

- Physical schema can be changed without changing application:
- DBMS must change mapping from conceptual to physical.

- Referred to as **physical data independence**.

External Data Level

In the relational model, the **external schema** also presents data as a set of relations. An external schema specifies a **view** of the data in terms of the conceptual level. It is tailored to the needs of a particular category of users. Portions of stored data should not be seen by some users and begins to implement a level of security and simplifies the view for these users

Examples:

- Students should not see faculty salaries.
- Faculty should not see billing or payment data.

Information that can be derived from stored data might be viewed as if it were stored.

- GPA not stored, calculated when needed.

Applications are written in terms of an external schema. The external view is computed when accessed. It is not stored. Different external schemas can be provided to different categories of users. Translation from external level to conceptual level is done automatically by DBMS at run time. The conceptual schema can be changed without changing application:

- Mapping from external to conceptual must be changed.
- Referred to as **conceptual data independence**.

Data Independence

A major objective for three-level architecture is to provide data independence, which means that upper levels are unaffected by changes in lower levels.

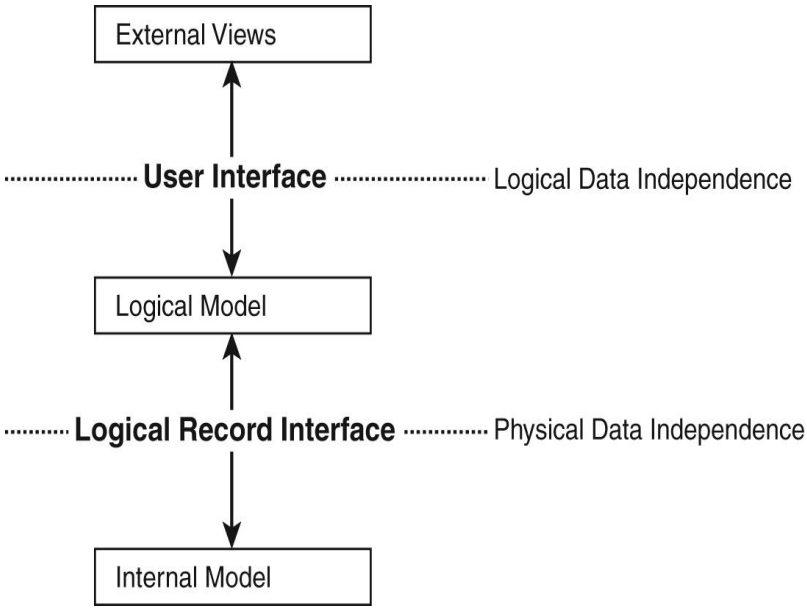
Logical data independence

- Immunity of external models to changes in the logical model
- Occurs at user interface level

Physical data independence

- Immunity of logical model to changes in internal model

- Occurs at logical interface level



DBMS Languages:

To provide the various facilities to different types of users, a DBMS normally provides one or more specialized programming languages called database languages i.e. set of syntax and semantics which allows database users to access the DBMS.

Data Definition Language-DDL

Data Definition Language (DDL) statements are used to define the database structure or schema.

Some examples:

- CREATE - to create objects in the database
- ALTER - alters the structure of the database
- DROP - delete objects from the database
- TRUNCATE - remove all records from a table, including all spaces allocated for the records are removed
- COMMENT - add comments to the data dictionary
- RENAME - rename an object

Data Manipulation Language (DML)

Data Manipulation Language (DML) statements are used for managing data within schema objects.

Some examples:

- SELECT - Retrieve data from the a database
- INSERT - Insert data into a table
- UPDATE - Updates existing data within a table
- DELETE - deletes all records from a table, the space for the records remain
- MERGE - UPSERT operation (insert or update)

Data Retrieval Language(DRL)

Statement is used to fetch the records
Select

Data Control Language (DCL)

Data Control Language (DCL) statements.

Some examples:

- GRANT - gives user's access privileges to database
- REVOKE - withdraw access privileges given with the GRANT command

Transaction Control (TCL)

Transaction Control (TCL) statements are used to manage the changes made by DML statements. It allows statements to be grouped together into logical transactions.

Some examples:

- COMMIT - save work done
- SAVEPOINT - identify a point in a transaction to which you can later roll back
- ROLLBACK - restore database to original since the last COMMIT
- SET TRANSACTION - Change transaction options like isolation level and what rollback segment to use