OVERVIEW OF DATABASE MANAGEMENT SYSTEM

- **Data :** Known facts that can be recorded and that have implicit meaning.
- For eg : Consider the names, phone numbers, and the address of the people.
- This collection of related data with an implicit meaning is a database.

Database :

- A database is a collection of related data.
- A database represents some aspects of the real world, sometimes called as mini world. Changes to the mini world are reflected in the database.
- A database is a logically coherent collection of data with some inherent meaning
- A database can be of any size and complexity
- An eg. Of a large commercial database is Amazon.com . It contains data for over millions of active users, books, electronic items etc
- A database may be generated and maintained manually or it may be computerized
- A computerized database may be created and maintained either by a group of application programs or by a database management system.

• A **database management system (DBMS)** is a computerized system that enables users to create and maintain a database.

• **DBMS** is a ***general purpose software system that facilitates the process of defining, constructing, manipulating and sharing database among various users and applications***

• **Defining** a database involves specifying the data types, structures, and constraints of the data to be stored in the database.

• Database definition or descriptive information is also stored by DBMS in the form of a database catalog or dictionary and it is called as **metadata (data about data)**

• Constructing database is the process of storing the data on some storage medium that is controlled by DBMS.

• Manipulating a database includes functions such as querying the database to retrieve specific data, updating the database

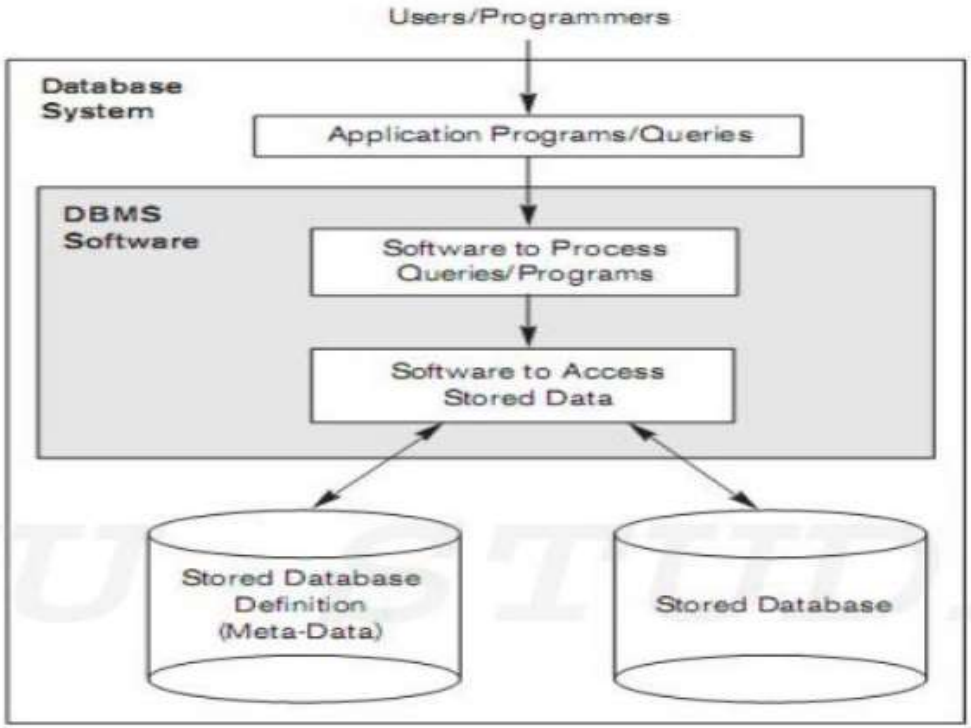
• Sharing a database allows multiple users and programs to access the database simultaneously.

• Other important functions provided by DBMS include protecting the database and maintaining it over a long period of time.

• Protection includes the system protection against hardware or software malfunction and security protection against the unauthorized access.

• The primary goal of a DBMS is to provide a way to store and retrieve database information that is both convenient and efficient.

Simplified database system environment



- Users or programmers can access the dbms software by using application programs or queries
- In DBMS software , it contains :
    - Software to process the queries
    - Software to access the stored data
- DBMS software can access the data from the stored database.

Typical File System V/S DBMS

- In typical file processing system, permanent records stored in various files.
- Limitations of File System are :
    - Data redundancy
    - Data inconsistency
    - Unsharable data
    - Unstandardized data
    - Insecure data
    - Incorrect data

- DBMS can overcome all these limitations
- DBMS features to manage the data in robust and efficient manner
- In DBMS,
    - Avoid redundancy
    - Avoid inconsistency
    - Shared data
    - Standardized data
    - Provide security in data

CHARACHTERISTICS OF DATABASE APPROACH

• In db approach , a single repository maintains data that is defined once and then accessed by various users repeatedly through queries, transactions, and application programs.

• The main characteristics are :

- Self describing nature of database system
- Insulation between programs and data, and data abstraction
- Support of multiple views of the data
- Sharing of the data and multiuser transaction processing

1. **Self describing nature of database system**

• Database system contain not only the database itself but also a complete definition or description of database structure and constraints.

• This definition is stored in the dbms catalog which contains the information such as structure of each file, the type and the storage format of each data item

• The information stored in the catalog is called **meta data**

• Rather the data is stored as self describing data that includes the data item names and data values together in one structure

2. **Insulation between programs and data, and data abstraction**

• The structure of data files is stored in the DBMS catalog separately from the access programs.

• This property is called **program-data independence**

• An operation (also called a function or method) is specified in two parts.

- **Interface** : The interface of an operation includes the operation name and the data types of its arguments
- **Implementation** : is specified separately and can be changed without affecting the interface.

• The characteristic that allows program-data independence and program operation independence is called **data abstraction.**

• A data model is a type of data abstraction that is used to provide conceptual representation

• In database approach detailed structure and organization of each file are stored in a catalog

3. **Support of multiple views of the data**

• A database has many type of users, each user may require a different perspective or **view** of the database.

• A view may be a subset of the database or it may contain virtual data that is derived from the database files but is not explicitly stored.

• For eg : In a library management system in college

  • User1→ Admin : Admin includes the details like user accounts, fine management, book acquisition records, and system logs

  •User 2→ Librarian : Librarian focuses book availability, issue records, and due dates

  • User 3 → Students : For members only shows the book issued to them and their due dates

4. **Sharing of the data and multiuser transaction processing**

• DBMS must include concurrency control software

  • to ensure that several users trying to update the same data do so in a controlled manner so that the result of the updates is correct

• DBMS must enforce several transaction properties

  ▫ Isolation property : Ensures that each transaction appears to execute in isolation from other transactions even though hundreds of transactions may be executing concurrently.

  ▫ Atomicity property : Ensures that either all the database operations in a transaction are executed or none In this case we have to ensure that data should be restored to a consistent state

DATABASE USERS

- Several db users are :
  - Database Admin
  - Database Designers
  - System Analysts and Application Programmers
  - End Users

1. Database Administrator (DBA)

- Chief administrator to oversee and manage the resources
- Administering the resources is the responsibility of a DBA
- Responsible for authorizing access to the database, coordinating and monitoring its use.
- Also acquiring software and hardware resources
- DBA should be responsible for the problems such as security breaches and poor system response time

2. Database Designers

- DB designers are responsible for identifying the data to be stored in the database
- Choose the appropriate structures to represent and store this data
- Responsible to communicate with all perspective db users in order to understand their requirements (ie, how the data to be stored, processed and how it reused)
- Also responsible for creating a design that meets all these requirements
- They interact with each group of users and develop views.

3. End Users

- They are the people whose jobs require access to the database for querying , updating, and generating reports, the database primarily exists for their use
- Several categories of end users are :
    - Casual End Users
    - Naïve Users
    - Sophisticated End Users
    - Standalone Users

a) Casual End Users

- Occasionally access the database, but they may need different information each time
- They use a sophisticated database query interface to specify their requests and are typically middle or high level managers.

b) Naïve Users

- Also called parametric end users
- Their main job function is constantly querying and updating the database.
- A few examples are :
    - Bank customers check account balances and post withdrawals and deposits
    - Social media users post and read items on social media web sites

c) Sophiticated End Users

• Include engineers, scientists, business analysts and others who thoroughly familiarize themselves with the facilities of DBMS

• They are familiar with the database and they implement their own applications

d) Standalone Users

• Maintain personal database by using ready made program packages, that provide easy to use menu based or graphics based interfaces.

• An example is the user of a financial software package that stores a variety of personal financial data.

4. System Analysts and Application programmers (Software Engineers)

- **System analyst** determine the requirements of end users , especially the naïve users
- Develop specifications for standard canned transactions that meet their requirements.
- **Application Programmers** implement these specifications as programs
- Then they test, debug, document, and maintain these canned transactions
- Such analysts and programmers commonly referred to as software developers or software engineers

Advantages of DBMS

a) Controlling Redundancy

- In typical file system, redundancy in storing the same data multiple times may lead to several problems such as duplication of effort, storage space is wasted, files that represent the same data may become inconsistent
- In the db approach, the views of different user groups are integrated during the db design
- Ideally, we should have a database design that stores each logical data item is known as **data normalization ,** it ensures consistency and saves storage space

b) Restricting Unauthorized Access

- When multiple users share a large database , it is likely most users will not be authorized to access all information in the database
- A DBMS should provide a **security and authorization subsystem**

c) Providing persistent storage for program objects

- The persistent storage of program objects and data structures is an important function of a database systems
- Object oriented database systems offers data structure compatibility with one or more object oriented programming languages

d) Providing Storage Structures and Search Techniques for Efficient Query Processing

• Database systems must provide capabilities for efficiently executing queries and updates

•The query processing and optimization module of the DBMS is responsible for choosing an efficient query execution plan for each query based on the existing storage structures

e) Providing Backup and Recovery

• A DBMS must provide facilities for recovering from hardware or software failures.

• The backup and recovery subsystem of the DBMS is responsible for recovery

f) Providing Multiple User Interfaces

• Because many types of users with varying levels of technical knowledge use a database, a DBMS should provide a variety of user interfaces.

• These include

- query languages for casual users
- programming language interfaces for application programmers
- forms and command codes for parametric users
- menu-driven interfaces and natural language interfaces for standalone users

g) Representing Complex Relationships among Data

h) Enforcing Integrity Constraints

• New functionality being added to DBMS is :

- Scientific Applications
- Extensible Markup Language (XML)
- Image, Audio, Video Data Management
- Data Warehousing & Data Mining
- Spatial & Time Data Management

Disadvantages of DBMS

• In spite of the advantages of using a DBMS, there are a few situations in which a DBMS may involve unnecessary overhead costs

- High initial investment in hardware, software,and training
- Overhead for providing security, concurrency control, recovery, and integrity functions

STRUCTURED, SEMI STRUCTURED & UNSTRUCTURED DATA

- Datas are known facts that can be recorded and have an implicit meaning
- Eg . Are :
    - Name , Marks , Phone number , Age etc
- In DBMS , data can be categorized into 3, based on
    - how the data to be organized
    - how the data to be stored
    - how these data are to be accessed

And the categories are :

- Structured Data
- Semi Structured Data
- Un- Structured Data

Structured Data

• Structured data is data whose elements are addressable for effective analysis.

•It has been organized into a formatted repository that is typically a database.

• It concerns all data which can be stored in database SQL in a table with rows and columns.

• They have relational keys and can easily be mapped into pre-designed fields.

• Easy to query using SQL

• *Example:* Relationaldata.

Characteristics of Structured Data

- Data conforms to a data model and has easily identifiable structure
- Data is stored in the form of rows and columns **Example : Database**
- Data is well organised
- Data resides in fixed fields within a record or file
- Data elements are addressable, so efficient to analyse and process

Advantages of Structured Data:

- Easy to manage
- High level of consistency and integrity
- Enhanced data security

Disadvantages of Structured Data:

- Not Flexible for handling complex data types
- Expensive

Semi-Structured Data

- Semi-structured data is information that does not reside in a relational database but that has some organizational properties that make it easier to analyze.
- ie, it does not have strict table format , but it contains tags to separate data elements
- With some processes, you can store them in the relation database
- *Example*: XML data.

Characteristics of semi-structured Data:

- Data does not conform to a data model but has some structure.
- Data can not be stored in the form of rows and columns as in Databases
- It contains tags and elements which is used to group data and describe how the data is stored
- Similar entities are grouped together and organized in a hierarchy
- Entities in the same group may or may not have the same attributes or properties
- Does not contain sufficient metadata which makes automation and management of data difficult
- Size and type of the same attributes in a group may differ
- Due to lack of a well-defined structure, it can not used by computer programs easily

Advantages of Semi-Structured Data :

1. More flexible than structured data
2. Scalable
3. Easy to manage the nested data
4. Faster data processing

Disadvantages of Semi- Structured Data :

• Queries are less efficient as compared to structured data.

• Lack of standardization

• Semi-structured data can be more difficult to secure than structured data

Unstructured Data

Unstructured data is a data which is not organized in a predefined manner or does not have a predefined data model

•. So for Unstructured data, there are alternative platforms for storing and managing

• Ie, it requires advanced techniques (such as AI or ML) for processing

• *Example*: Word, PDF, Text, Media logs.

Characteristics of Unstructured Data

- **Lack of Format**: Unstructured data does not fit neatly into tables or databases
- **Variety**: This type of data can include a wide range of formats, such as: Text documents, Multimedia files, Social media content etc
- **Volume**: Unstructured data represents a significant portion of the data generated today. It is often larger in volume compared to structured data.

Advantages :

- It supports the data that lacks a proper format or sequence
- The data is not constrained by a fixed schema
- Very Flexible due to the absence of schema.
- Data is portable
- It is very scalable
- It can deal easily with the heterogeneity of sources.
- These types of data have a variety of business intelligence and analytics applications.

Disadvantages :

- Difficult to analyze without special tools

DATA MODELS, SCHEMAS, AND INSTANCES

• One fundamental characteristic of the database approach is that it provides some level of **data abstraction.**

• Data abstraction generally refers to the suppression of details of data organization and storage, and the highlighting of the essential features for an improved understanding of data

• **DATA MODEL**

- A collection of concepts that can be used to describe the structure of a database (how the data are to be logically structured, stored , accessed etc) that provides the means to **achieve abstraction**.
- Ie , the data abstraction which can be achieved by creating data models
- By structure of a database we mean the data types, relationships, and constraints that apply to the data.
- Most data models also include a set of basic operations for specifying retrievals and updates on the database
- In simple, data model consist of the structure as well as the basic operations

Categories of Data Models

• Data models which we can categorize according to the types of concepts they use to describe the database structure

- High-level or conceptual data models
- Low-level or physical data models
- Representational (or implementation) data models

1. **High-level or conceptual data models**

- Also called as **semantic model**
- It provide the concept that are close to the way many users perceive data.
- Ie, describes that how the users view the datas
- Conceptual data models use concepts such as entities, attributes, and relationships
- Eg : Entity Relationship Models (ER Models)

2. **Low-level or physical data models**

- It describes that how the datas are stored in the computer
- Ie, how the data is represented internally
- Eg : B Tree, Hashing techniques

3. **Representational (or implementation) data models**

- Provide the concepts that fall between above two models
- It is used by many commercial DBMS implementations
- Eg : Relational Model, Network Model etc

Database Schema

• The description of a database is called the **database schema**, which is specified during database design and is not expected to change frequently.

• 3 types of database schema are : Physical schema, logical schema, view schema

• Most data models have certain conventions for displaying schemas as diagrams.

• A displayed schema is called a **schema diagram (** illustrative display of db schema)

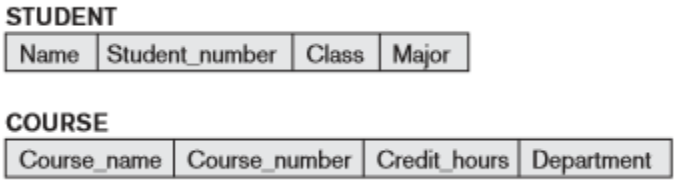


Fig : Schema Diagram for a database

• The diagram displays the structure of each record type but not the actual instances of records.

• And call each object in the schema—such as STUDENT or COURSE—a **schema construct**.

• Ie , component of the schema or it is an object within the schema

• The actual data in a database may change quite frequently

• The data in the database at a particular moment in time is called a **database state or snapshot.**

• It is also called the **current set of occurrences or instances** in the database.

THREE-SCHEMA ARCHITECTURE AND DATA INDEPENDENCE

• **Levels of Abstraction / 3 Schema Architecture /ANSI Architecture**

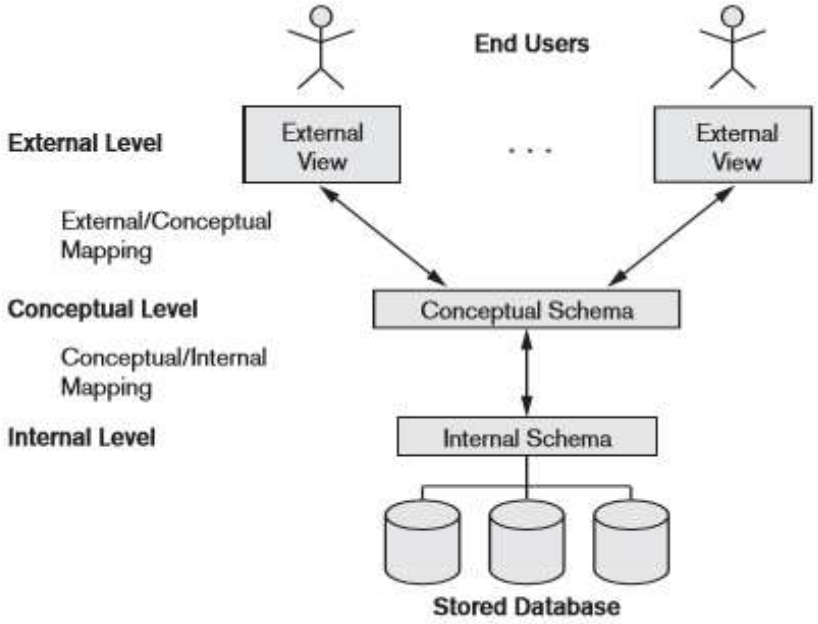
• It is a framework which is used to describe the structure of a specific database system

• The goal of the three-schema architecture is to separate the user applications from the physical database

• It seperates the database system into 3 levels to provide the data abstraction and data independence for the users and applications.

• It ensures data storage and user interaction remain distinct

• One of the main objective of thid architecture is to enable the multiple users to access the same data with a personalized view (and this can be achieved through the data abstraction)



Schemas can be defined at the following three levels:

1. **Internal Schema (Physical Schema)**

- The internal level has an internal schema ,which describes the physical storage structure of the database.
- The internal schema uses a physical data model and describes the complete details of data storage and access paths for the database.
- ie, it describes **how the data is physically stored in database** , including the data structures, file organizations
- There is no user interaction in this level
- Key Characteristics :
    - Handles efficiency , performance and storage management
    - Hidden from end users and application developers

2. **Conceptual Schema (Logical Schema)**

- The conceptual level has a conceptual schema, which **describes the structure of the whole database** for a community of users (ie, what data are to be used and what relationship exists among the datas)
- The conceptual schema hides the details of physical storage structures and concentrates on describing entities, data types, relationships, user operations, and constraints.
- Usually, a representational data model is used to describe the conceptual schema when a database system is implemented.
- This implementation conceptual schema is often based on a conceptual schema design in a high-level data model.
- Key characteristics of this level is it ensures consistency and integrity across applications

3. External Schema (View Schema)

- The external or view level includes a number of external schemas or user views.
- Each external schema describes the part of the database that a particular user group is interested in and hides the rest of the database from that user group.
- Ie, **it defines how specific users or applications view the data**
- As in the previous level, each external schema is typically implemented using a representational data model, possibly based on an external schema design in a high-level data model.
- Key Characteristics are :
    - Provides security by restricting access to sensitive data
    - Offers user friendly views of complex data

Mappings

• The DBMS must transform a request specified on an external schema into a request against the conceptual schema, and then into a request on the internal schema for processing over the stored database.

• If the request is a database retrieval, the data extracted from the stored database must be reformatted to match the user's external view.

• The processes of transforming requests and results between levels are called **mappings**.

• ie, **it describes how the 3levels actually correspond (relate) to each other**

• These mappings may be time-consuming

• Two types of mapping :

- **Conceptual / Internal Mapping**
  - It lies in between conceptual level and internal level
  - It is to define the correspondence between records , fields of conceptual level and files, data structures of internal level
- **External / Conceptual Mapping**
  - It lies in between external level and conceptual level
  - It is to define the correspondence between particular external level and conceptual view

DATA INDEPENDENCE

- The three-schema architecture can be used to further explain the concept of data independence, which can be defined as the **capacity to change the schema at one level of a database system without having to change the schema at the next higher level**
- Two types of data independence:
    - Logical data independence
    - Physical data independence

Logical Data Independence

- It is the capacity to change the conceptual schema without having to change external schemas or application programs.
- We may change the conceptual schema to expand the database (by adding a record type or data item), to change constraints, or to reduce the database (by removing a record type or data item)

Physical data independence

- It is the capacity to change the internal schema without having to change the conceptual schema.
- Hence, the external schemas need not be changed as well

Database Languages

- DBMS has appropriate languages to express the database queries and updates
- DB languages can be used to read, store and update the data in the database

1. Data Definition Languages (DDL)

- It is used to define database structure
- Ie, to create schema, tables , indexes and constraints in the db
- It is used by the DBA and by database designers to define both schemas.
- The DBMS will have a DDL compiler whose function is to process DDL statements in order to identify descriptions of the schema constructs and to store the schema description in the DBMS catalog.
- In DBMSs where a clear separation is maintained between the conceptual and internal levels ,the DDL is used to specify the conceptual schema only

- DDL Commands :
  - CREATE - Creates objects in database
  - ALTER - Alters the structure of database
  - TRUNCATE - Remove all records from table
  - DROP - To delete the objects from database
  - RENAME - Rename an object
  - COMMENT - Comment on data dictionary

2. Data Manipulation Languages

- Once the database schemas are compiled and the database is populated with data, users must have some means to manipulate the database.
- Typical manipulations include retrieval, insertion,deletion,and modification of the data.
- The DBMS provides a set of operations or a language called the data manipulation language (DML) for these purposes.
- ie, It is used for accessing and manipulating the data in a database
- It handles the user requests

- DML Commands :
    - SELECT - Retrieve the data from database
    - INSERT - Insert data into a table
    - UPDATE - Update the existing data within a table
    - DELETE - To delete all records from a table

3 . Data Control Languages

- It is used to retrieve the stored data
- DCL Commands are : GRANT - Give user access privilages to database
  REVOKE - To take back permissions from the user

DBMS Interfaces

- It is the mechanism that enable communication and interaction between database and its users , applications etc
- In other words, this will act as a bridge that facilitates the data retrieval, manipulation and management of data
- It allows for ability to input queries to a database without using query languages itself

- **User-friendly interfaces provided by a DBMS may include the following:**

1. Menu-Based Interfaces

- ***It is designed for Web Clients or Browsing*** .
- These interfaces present the user with lists of options (called menus) that lead the user through the formulation of a request.
- Menus do away with the need to memorize the specific commands and syntax of a query language; rather, the query is composed step-by step by picking options from a menu that is displayed by the system.
- ***Pull-down menus*** are a very popular technique in Web-based user interfaces. They are also often used in browsing interfaces, which allow a user to look through the contents of a database in an exploratory and unstructured manner.
- Key Features are :
    - Predefined options
    - Error reduction
    - Consistency
- One of the drawback is , limited flexibility and scalability (ie, users are restricted to predefined options

2. Forms-Based Interfaces.

- A forms-based interface displays a form to each user.
- Users can fill out all of the form entries to insert new data, or they can fill out only certain entries, in which case the DBMS will retrieve matching data for the remaining entries.
- Forms are ***usually designed and programmed for naive users*** as interfaces to canned transactions.
- Key Features are :
    - It makes user interactions straight forward
    - Validates the input data to reduce mistakes

3. Graphical User Interfaces.

- A GUI typically displays a schema to the user in diagrammatic form.
- The user then can specify a query by manipulating the diagram.
- In many cases, GUIs utilize both menus and forms.
- Most GUIs ***use a pointing device***, such as a mouse, to select certain parts of the displayed schema diagram.
- Key features are :
    - Visual representation of data
    - Simplified Query Execution
    - Error handling and validation

4. Natural Language Interfaces.

- These interfaces accept requests written in English or some other language and attempt to understand them.
- A natural language interface usually has its own
- The natural language interface refers to the words in its schema, as well as to the set of standard words in its dictionary, to interpret the request.
- If the interpretation is successful, the interface generates a high-level query corresponding to the natural language request and submits it to the DBMS
- Key features are :
    - Language Parsing (ie, system translates the natural language to structured database queries)
    - It provide flexibility and efficiency

One of the drawback in this interface is ambiguity

5. Speech Input and Output.

- Allows the users to interact with database system through spoken commands and responses
- Limited use of speech as an input query and speech as an answer to a question or result of a request is becoming common
- The speech input is detected using a library of predefined words and used to set up the parameters that are supplied to the queries.
- For output, a similar conversion from text or numbers into speech takes place.

THE DATABASE SYSTEM ENVIRONMENT

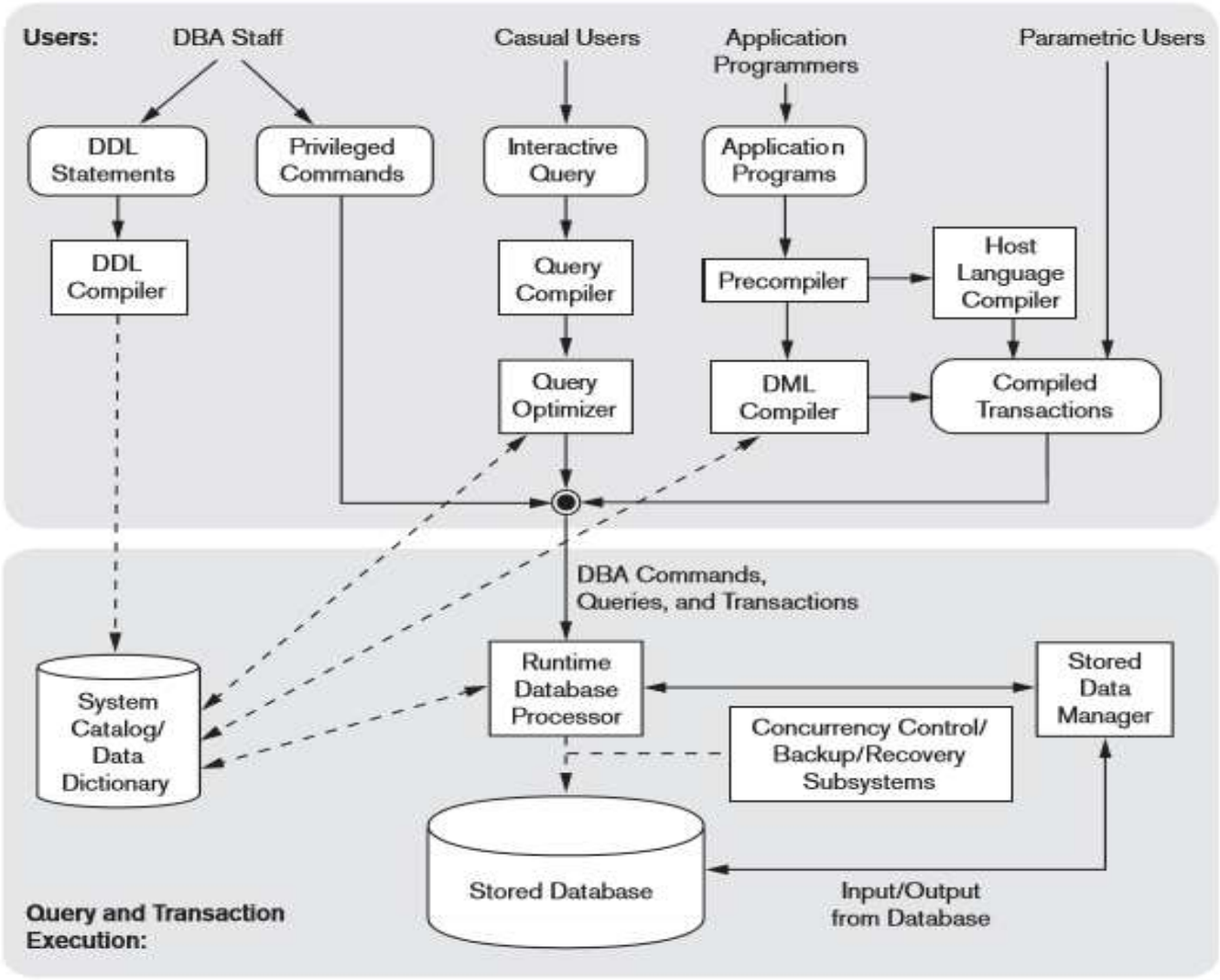


Figure 2.3
Component modules of a DBMS and their interactions.

DBMS Component Modules

- The figure is divided into two parts.
- The top part of the figure refers to the various users of the database environment and their interfaces.
- The lower part shows the internals of the DBMS responsible for storage of data and processing of transactions.

Consider the top part of Figure :

- It shows interfaces for the DBA staff, casual users who work with interactive interfaces to formulate queries, application programmers who create programs using some host programming languages
- . The DDL compiler processes schema definitions, specified in the DDL, and stores descriptions of the schemas (meta-data) in the DBMS catalog.
- The catalog includes information such as the names and sizes of files, names and data types of data items, storage details of each file, mapping information among schemas, and constraints
- Casual users and persons with occasional need for information from the database interact using some form of interface, which we call the interactive query interface
- These queries are parsed and validated for correctness of the query syntax by a query compiler that compiles them into an internal form.
- This internal query is subjected to query optimization
- The query optimizer is concerned with the rearrangement and possible reordering of operations, elimination of redundancies, and use of correct algorithms and indexes during execution

- The precompiler extracts DML commands from an application program written in a host programming language.
- These commands are sent to the DML compiler for compilation into object code for database access.
- The rest of the program is sent to the host language compiler.
- The object codes for the DML commands and the rest of the program are linked, forming a canned transaction whose executable code includes calls to the runtime database processor.

In the lower part of Figure

- The runtime database processor executes
  (1) the privileged commands
  (2) the executable query plans
  (3) the canned transactions with runtime parameters.
- It works with the system catalog and may update it with statistics.
- It also works with the stored data manager, which in turn uses basic operating system services for carrying out low-level input/output (read/write) operations between the disk and main memory.
- The runtime database processor handles other aspects of data transfer, such as management of buffers in the main memory
- Concurrency control and backup and recovery systems separately as a module and they are integrated into the working of the runtime database processor for purposes of transaction management.
- On the other hand, if the computer system is mainly dedicated to running the database server, the DBMS will control main memory buffering of disk pages.
- The DBMS also interfaces with compilers for general purpose host programming languages, and with application servers and client programs running on separate machines through the system network interface.

DATABASE ARCHITECTURES

- A Database stores a lot of critical information to access data quickly and securely. Hence it is important to select the correct architecture for efficient data management.

- DBMS Architecture helps users to get their requests done while connecting to the database.

- Choose database architecture depending on several factors like the size of the database, number of users, and relationships between the users.

- DBMS architecture depends upon how users are connected to the database to get their request done.

- Database architectures refers to the structural design of a database system, which dictates how the data stored, accessed, managed and manipulated.

- DBMS architecture are of different types

    (1) Centralized database

    (2) Basic client/server architecture

    (3) Two tire client server architecture

    (4) Three and n-tire architecture for web applications

1. **Centralized Database**

• A Centralized Database is a type of database that is stored, located as well as maintained at a single location only.

• This type of database is modified and managed from that location itself.

• The centralized location is accessed via an internet connection (LAN, WAN, etc).

• This centralized database is mainly used by institutions or organizations.

• Centralized database architecture can be beneficial for businesses and institutions that need to manage large amounts of data across multiple locations.

• It can help with:

    - **Data consistency**
    - **Data governance**

Data Consistency :

• In Centralized Database, all data are stored in a single central repository

• This reduces the duplication of data, and it ensures that all users access the same, updated and accurate information

• Eg : In a banking system, it ensures that customer's account balance remains consistent across all branches

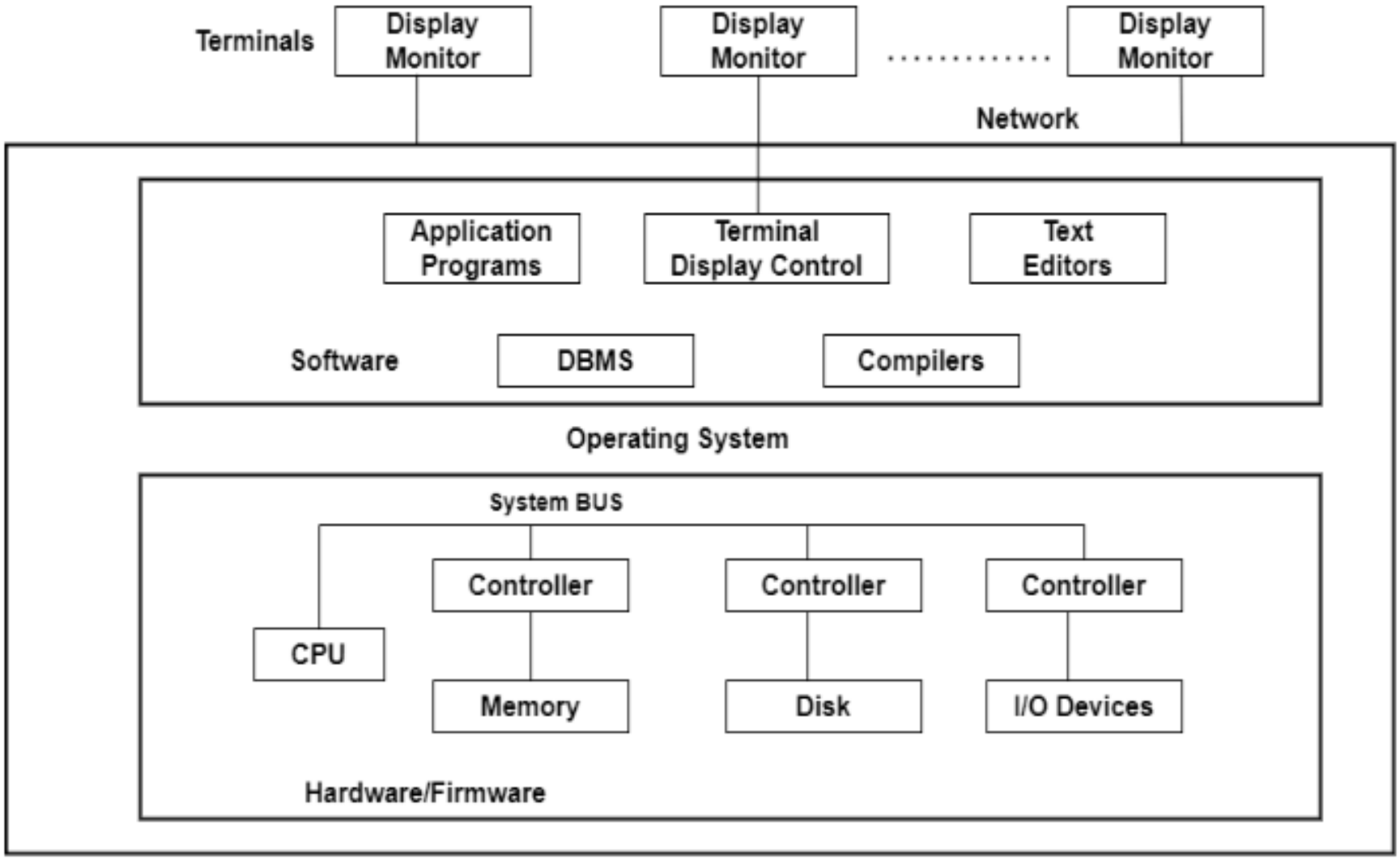
Data Governance:

• It helps to ensure control and effective management of data

• Eg : If government uses a centralized database, it can ensure lawful usage of data and prevent the unauthorized access of data

So, Key features are :

- Easy to manage
- Accuracy and reliability
- Security



Centralized architecture of DBMS

Advantages

• Since all data is stored at a single location only thus it is easier to access and coordinate data.

• The centralized database has very minimal data redundancy since all data is stored in a single place.

• It is cheaper in comparison to all other databases available.

• Easy to manage and backup

Disadvantages

• The data traffic in the case of a centralized database is more.

• If any kind of system failure occurs in the centralized system then the entire data will be destroyed.

• Limited Scalability

2. Basic Client / Server Architecture

- In the client-server architecture, when the client computer sends a request for data to the server through the internet, the server accepts the requested process and delivers the data packets requested back to the client.
- **Client** is a user machine that provide user interface capabilities and local processing (Sends requests to the server, typically SQL queries, and presents the results to the user)
- **Server** system provide service to client such as file (Processes the queries, retrieves the data from the database, and sends it back to the client)

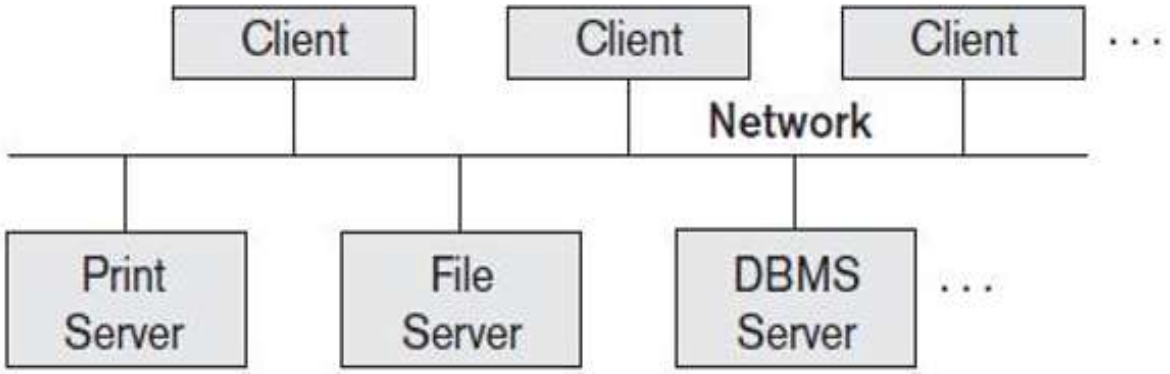


Fig : Logical Two Tier Architecture

a) Two-Tier Client Server Architecture

- Here, the term "two-tier" refers to our architecture's two layers-the Client layer and the Data layer.
- There are a number of client computers in the client layer that can contact the database server.

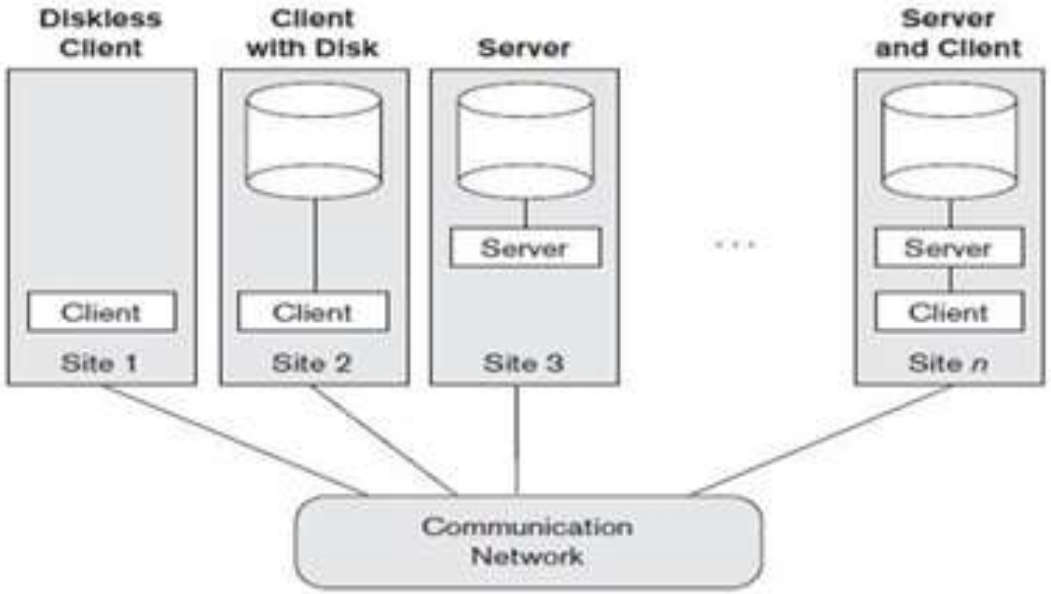


Fig : Physical Representation of two tier architecture

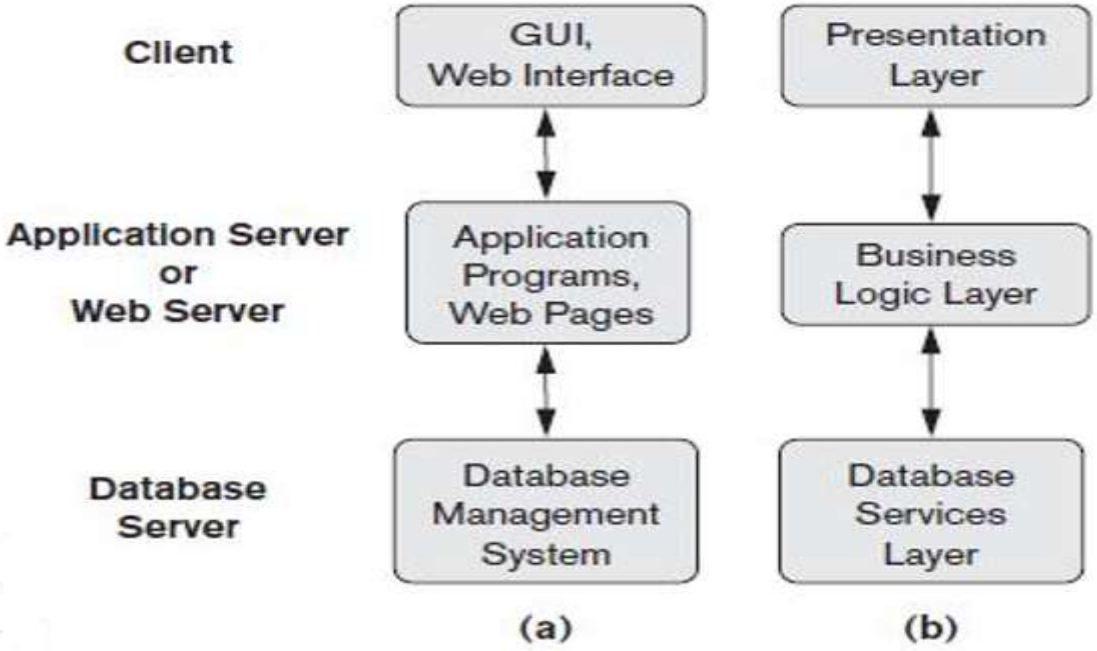
- Created a logical division between client and server
- Client Side :
    - User interface and application programs
- Server Side :
    - Query server and transaction server
- Application Program Interface (API) to access server databases
    - ODBC (Open Database Connectivity Standard)
    - JDBC (for Java Programming Interface)

b) Three-Tier Client-Server Architecture

• The Application Server / Business Logic Layer is an additional layer that serves as a link between the Client layer and the Data layer in this instance.

• The layer where the application programs are processed is the business logic layer, unlike a Two-tier architecture, where queries are performed in the database server.

• Here, the application programs are processed in the application server itself.



In Fig (a) ,

- This intermediate layer or middle tier is called the application server or the Web server, depending on the application.
- This server plays an intermediary role by running application programs and storing business rules (procedures or constraints) that are used to access data from the database server.
- It can also improve database security by checking a client's credentials before forwarding a request to the database server.
- The intermediate server accepts requests from the client, processes the request and sends database queries and commands to the database server, and then acts as a conduit for passing (partially) processed data from the database server to the clients
- Thus, the user interface, application rules, and data access act as the three tiers

In Fig (b) ,

- The presentation layer displays information to the user and allows data entry.
- The business logic layer handles intermediate rules and constraints before data is passed up to the user or down to the DBMS.
- The bottom layer includes all data management services.
- The middle layer can also act as a Web server, which retrieves query results from the database server and formats them into dynamic Web pages that are viewed by the Web browser at the client side.

Advantages

- ***Centralized Management***
- ***Scalability*** : Can handle multiple clients simultaneously
- ***Flexibility*** : Clients can run on different platforms
- ***Data Integrity*** : Server ensures that all data manipulations are consistent and follow the db schema
- ***Enhances Security***

Disadvantages

- ***Network dependency*** : A reliable network is required for communication between clients and servers
- ***High traffic overhead***
- ***Complexity in multi tier systems***

Features	Two Tier Architecture	N- Tier Architecture
Definition	Direct interaction between Client and DB Server	Intermediate layers exist between client and DB Server
Scalability	Limited	Highly Scalable
Security	Database directly exposed	Database secured by applications server
Complexity	Simple	Complex due to multiple layers
Performance	Fast for small applications	Better suited for large scale applications with high concurrency
Structure	Two Layers: Client and Server	Three or more Layers : Presentation, Application and Database Layers
Maintenance	Simple to maintain	More Complex
Flexibility	Less Flexible	Highly Flexible
Cost	Cost effective for small systems	High cost
Examples	Desktop Database Applications	Web based applications(e- commerce or online banking)

CLASSIFICATION OF DBMS

- Database management systems can be classified based on several criteria, such as

1. **Classification Based on Data Model**
2. **Classification Based on Users**
3. **Classification Based on Database Distribution**
4. **Classification Based on Costs**

1. **Classification Based on Data Model**

- Data models in DBMS are classified into several types, including:

a) Relational Data Model (SQL Systems)

b) Object Data Model

c) Object Relational Data Model

d) Hierarchical Data Model

e) Network Data Model

f) Flat Data Model

g) Big Data Systems (NoSQL Systems)

a) Relational Data Model (SQL Systems)

- The most popular data model today
- A relational database is defined as a group of independent tables which are linked to each other using some common fields of each related table.
- This model can be represented as a table with columns and rows.
- ***Tables*** are also known as ***relations***
- Each ***row*** is known as a ***tuple***.
- Each table of the ***column*** has a name or ***attribute***.
- It is well knows in database technology because it is usually used to represent real-world objects and the relationships between them.
- Relational model makes the query much easier than in hierarchical or network database systems
- Some popular relational databases are used nowadays like Oracle, Sybase, DB2, MySQL Server etc

Relational Model Terminologies:

Relation	Table
Tuple	Row / Record
Attribute	Column / Feild
Domain	It consist of set of legal values
Cardinality	It consists of number of rows
Degree	It consists of number of columns

- The relational model represents how data is stored in Relational Databases.
- A relational database consists of a collection of tables, each of which is assigned a unique name.
- Consider a relation ***STUDENT*** with attributes ***ROLL_NO, NAME, ADDRESS, PHONE, and AGE*** shown in the table.

Table Student

ROLL_NO	NAME	ADDRESS	PHONE	AGE
1	RAM	DELHI	9455123451	18
2	RAMESH	GURGAON	9652431543	18
3	SUJIT	ROHTAK	9156253131	20
4	SURESH	DELHI		18

- **Attributes** : ROLL_NO, NAME, ADDRESS, AGE, PHONE

- **Data Item** **:** The smallest unit of data in the relation is the individual data item. It is stored at the intersection of rows and columns are also known as cells.

- **Tuple** **:** The above relation contains 4 tuples, one of which is shown as:

1	RAM	DELHI	9455123451	18

- **Column** **:** The column ROLL_NO is extracted from the relation STUDENT.

ROLL_NO
1
2
3
4

- **Degree :**

  - It consists of no. of attributes or columns
  - The STUDENT relation defined above has degree 5.
  - The degree of a relation doesn't change with time as tuples get added or deleted.
  - Ie, degree of a relation is fixed and based only on no.of attributes.
    - 1 attribute → Unary relation (degree=1)
    - 2 attributes → Binary relation (degree=2)
    - 3 attributes → Ternary relation (degree=3)
    - n attributes → N-Ary relation (degree= n)

- **Cardinality :**
  - It consists of number of tuples or rows
  - The STUDENT relation defined above has cardinality 4.
  - Adding or deleting tuples will change the cardinality .
- **NULL Values :**
  - The value which is not known or unavailable is called a NULL value.
  - It is represented by blank space.
  - e.g.; PHONE of STUDENT having ROLL_NO 4 is NULL.
- **Domain :**
  - It contains a set of atomic values that an attribute can take.
  - It could be accomplish explicitly by listing all possible values or specifying conditions that all values in that domain must be confirmed.
  - **For example :** the domain of gender attributes is a set of data values "M" for male and "F" for female.

- **Relation Schema :**
    - A relation schema defines the structure of the relation and represents the name of the relation with its attributes.
    - e.g.; STUDENT (ROLL_NO, NAME, ADDRESS, PHONE, and AGE) is the relation schema for STUDENT.
    - If a schema has more than 1 relation, it is called Relational Schema.

- **Relational instance :**
    - In the relational database system, the relational instance is represented by a finite set of tuples.
    - Relation instances do not have duplicate tuples.

- **Relational key :**
    - In the relational key, each row has one or more attributes.
    - It can identify the row in the relation uniquely.

PROPERTIES OF RELATIONS

- Each attribute in a relation has only one data value corresponding to it i.e. they do not contain two or more values.
- Name of the relation is distinct from all other relations.
- Each relation cell contains exactly one atomic (single) value
- Each attribute contains a distinct name
- Attribute domain has no significance
- Tuple has no duplicate value
- Order of tuple can have a different sequence
- It also provides information about metadata.

ADVANTAGES OF THE RELATIONAL MODEL

- **Simple model :** Relational Model is simple and easy to use.
- **Flexible :** Relational Model is more flexible than any other relational model present.
- **Secure:** Relational Model is more secure than any other relational model.
- **Data Accuracy:** Data is more accurate in the relational data model.
- **Data Integrity:** The integrity of the data is maintained in the relational model.
- **Operations can be Applied Easily**

DISADVANTAGES OF THE RELATIONAL MODEL

- Relational Database Model is not very good for large databases.
- Sometimes, it becomes difficult to find the relation between tables.
- Because of the complex structure, the response time for queries is high.

b) Object Data Model

- In Object Oriented Data Model, data and their relationships are contained in a single structure which is referred as object in this data model.
- In this, real world problems are represented as objects with different attributes.
- All objects have multiple relationships between them.

Advantages of Object Oriented Data Model :

- Codes can be reused due to inheritance.
- Easily understandable.
- Cost of maintenance can reduced due to reusability of attributes and functions because of inheritance.

Disadvantages of Object Oriented Data Model :

It is not properly developed so not accepted by users easily.

c) Object Relational Data Model (ORDBMS)

- It is a database system that combines the advantages of an object-oriented programming model with the efficiency of a relational database system.
- It is useful for managing and organizing complex data, especially when the data relationships are complicated

Advantages of ORDBMS

- **SQL Support:** It supports the structures of the SQL query language, are quite flexible and make it easier to handle complex queries.
- **Scalability:** It is easier and can accommodate large data sets.
- **Interoperability**

Disadvantages of ORDBMS

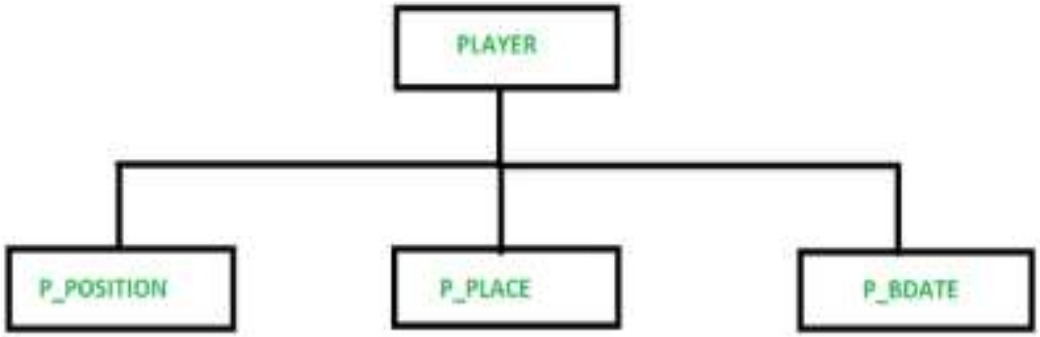
- **Complexity in Implementation**

d) Hierarchical Data Model

- A hierarchical model represents the data in a tree-like structure
- In this model , data is stored in the form of records (or nodes) with parent – child relationships
- In a hierarchical model, data are viewed as a collection of tables

- Key Features :
    - Data is represented as a tree
    - `Each record has one parent and can have multiple children
    - Root node represents the top of the hierarchy, and all other nodes descend from it
    - Relationships between data elements are defined at the schema level
    - Accessing data requires navigating the hierarchy from the root node to the desired child node.

Example 1: Consider the below cricket database system hierarchical model scheme.



Structure :

Nodes : Represent the individual records or data items

Edges : Represent relationships between parent and child nodes

Advantages of the hierarchical model :

- It has a very simple hierarchical database structure.
- It has data sharing as all data are held in a common database data and therefore sharing of data becomes practical.
- It offers data security and this model was the first database model that offered data security.
- Also offers data integrity as it is based on the parent-child relationship and also there's always a link between the parents and the child segments.
- Data is easily accessed due to its predefined structure

Disadvantages of the hierarchical model :

- Lack of flexibility
- Data Redundancy , due to the strict parent - child relationships
- Cannot handle many- to- many relationships efficiently

e) Network Data Model

- It is a data model that allows the representation of ***many-to-many relationships***
- Like a hierarchical model, this model also does not have any database standard
- And this model allows to represent multi parent relationships.
- It is not commonly used due to its complexity.

f) Flat Data Model

- It is a simple data model that stores all data in a single table with columns and rows.

g) NoSQL DBMS

- It is designed for handling large volumes of unstructured or semi-structured data.
- Includes document databases, key-value stores, column-family stores, and graph databases.
- Data access varies depending on the specific NoSQL type.

2. Classification Based on Users

a) Single-User Database Systems

- A single-user database system is designed to be used by only one user at a time.
- Simple, but they are not suitable for environments where multiple users need to access the same data at the same time.
- **Example:** Personal Computers

Advantages :

- Simplicity
- Lower Costs
- Less Complexity

Disadvantages :

- Limited Scalability
- Not Ideal for Large Data Handling

b **) Multi-user Database Systems**

- It can be accessed by multiple users simultaneously..
- They are more complex and require more resources than single-user systems, but they are essential for organizations where multiple users need to access the same data at the same time.
- **Example:** Databases of Banks, insurance agencies, stock exchanges, supermarkets, etc.

Advantages :

- Concurrency
- Scalability
- Data Consistency and Integrity

Disadvantages :

- Higher Complexity
- Cost
- Performance Overhead

3. Classification Based on Database Distribution

Databases can be classified based on distribution as either homogeneous or heterogeneous distributed databases

a) Homogeneous Database:

- In a homogeneous database, all different sites store database identically. ie, use the same DBMS software from multiple sites
- Data exchange between these various sites can be handled easily.
- Hence, they're easy to manage.

b) Heterogeneous Database:

- Different sites might use different DBMS software, but there is additional common software to support data exchange between these sites.