1.1 INTRODUCTION TO DATABASE

A database is defined as a collection of logically related data stored together that is designed to meet the information needs of an organization.

Database can further be defined as, it :

(i) Is a collection of interrelated data stored together without harmful or unnecessary redundancy.

(ii) Serves multiple applications in which each user has his own view of data. This data is protected from unauthorized access by security mechanism and concurrent access to data is provided with recovery mechanism.

(iii) Stores data independent of programs and changes in data storage structure or access strategy do not require changes in accessing programs or queries.

A database consists of the following four components as shown in fig.

(i) Data item

(ii) Relationships

(iii) Constraints

(iv) Schema

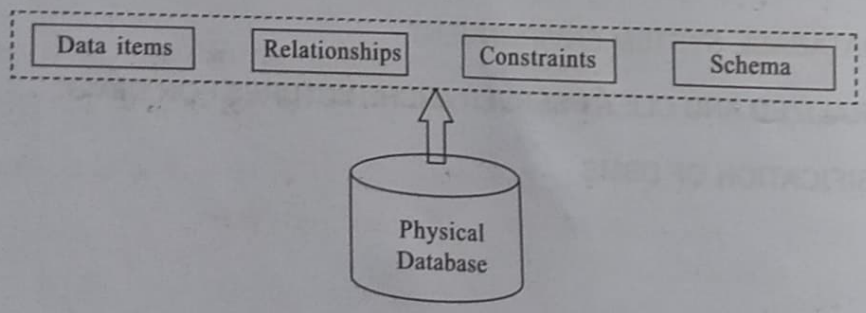


FIG 1.1 : Components of Database

Database is nothing but collection of files or records. A data base is a collection of data describing the activities of one or more organizations.

A database is a collection of related data.

(OR)

A database is a collection of information that is organized so that it can be easily accessed, managed and updated.

History of Database Systems :

1950s and early 1960s :

- Magnetic tapes were developed for data storage.
- Data processing tasks such as payroll were automated, with data stored on tapes.
- Data could also be input from punched card decks, and output to printers.
- **Late 1960s and 1970s :** The use of hard disks in the late 1960s changed the scenario for data processing greatly, since hard disks allowed direct access to data.
- With disks, network and hierarchical databases could be created that allowed data structures such as lists and trees to be stored on disk. Programmers could construct and manipulate these data structures.
- With disks, network and hierarchical databases could be created that allowed data structures such as lists and trees to be stored on disk. Programmers could construct and manipulate these data structures.
- In the 1970's the EF CODD defined the Relational Model.

In the 1980's :

- Initial commercial relational database systems, such as IBM DB2, Oracle, Ingress, and DEC Rdb, played a major role in advancing techniques for efficient processing of declarative queries.
- In the early 1980s, relational databases had become competitive with network and hierarchical database systems even in the area of performance.
- The 1980s also saw much research on parallel and distributed databases, as well as initial work on object-oriented databases.

Early 1990s :

- The SQL language was designed primarily in the 1990's.
- And this is used for the transaction processing applications.
- Decision support and querying re-emerged as a major application area for databases.
- Database vendors also began to add object-relational support to their databases.

Late 1990s :

- The major event was the explosive growth of the World Wide Web.

- Databases were deployed much more extensively than ever before. Database systems now had to support very high transaction processing rates, as well as very high reliability and 24*7 availability (availability 24 hours a day, 7 days a week, meaning no downtime for scheduled maintenance activities).
- Database systems also had to support Web interfaces to data.

Database Properties

A database has the following properties :

- It is a representation of some aspect of the real world or a collection of data elements (facts) representing real-world information.
- A database is logical, coherent and internally consistent.
- A database is designed, built and populated with data for a specific purpose.
- Each data item is stored in a field.
- A combination of fields makes up a table. For example, each field in an employee table contains data about an individual employee.

A database can contain many tables. For example, A student database contains student table and department table. Student table contains information about its entities such as name, pin, branch and marks etc.

Database Management System

A database management system (DBMS) is a collection of programs that enables users to create and maintain databases and control all access to them. The primary goal of a DBMS is to provide an environment that is both convenient and efficient for users to retrieve and store information.

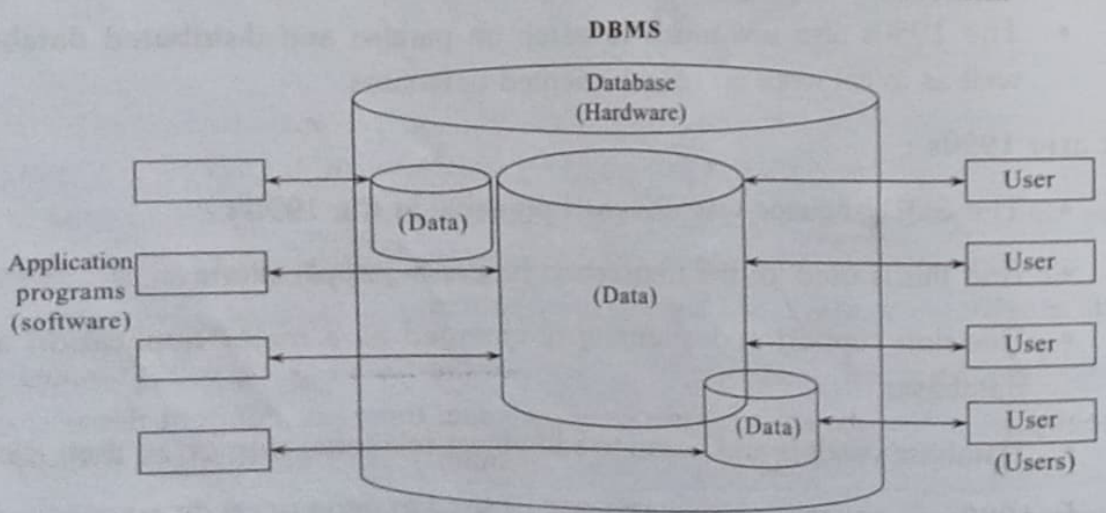


FIG 1.2 : Structure of DBMS Components

With the database approach, we can have the traditional banking system as shown in below figure. In this bank example, a DBMS is used by the Personnel Department, the Account Department and the Loan Department to access the shared corporate database.

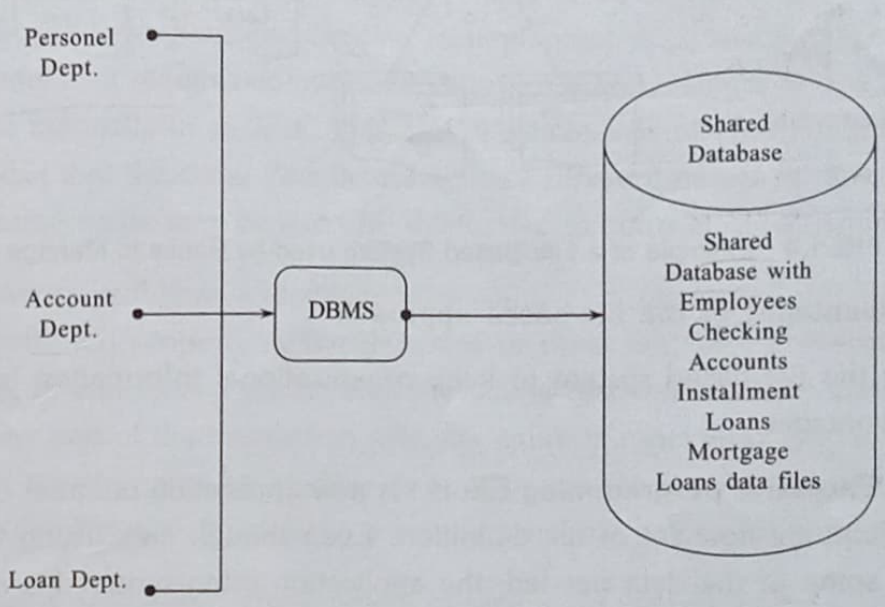


FIG 1.3 : Example of Traditional Banking System

1.2 EVOLUTION OF DBMS

The way in which computers manage data has come a long way over the last few decades. Today's users find many benefits in a database system. Before coming to DBMS there exist traditional file system approach.

File-based System

One way to keep information on a computer is to store it in permanent files. A company system has a number of application programs; each of them is designed to manipulate data files. These application programs have been written at the request of the users in the organization. New applications are added to the system as the need arises. The system just described is called the file-based system.

Consider a traditional banking system that uses the file-based system to manage the organization's data shown in Figure. As we can see, there are different departments in the bank. Each has its own applications that manage and manipulate different data files. For banking systems, the programs may be used to debit or credit an account, find the balance of an account, add a new mortgage loan and generate monthly statements.

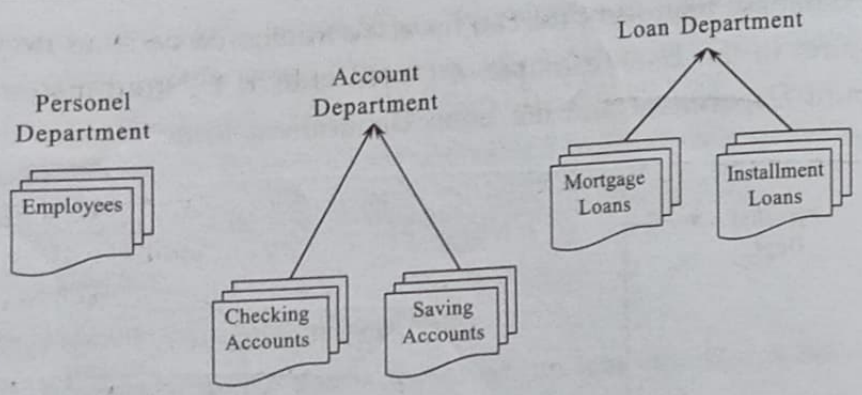


FIG 1.4 : Example of a File-Based System used by Banks to Manage Data

Disadvantages of the file-based approach

Using the file-based system to keep organizational information has a number of disadvantages.

1. **Excessive programming Effort :** A new application program often required an entirely new set of file definition. Even though an existing file may contain some of the data needed, the application often required a number of other data items. As a result, the programmer had to recode the definitions of needed data items from the existing file as well as definitions of all new data items. Thus in file-oriented systems, there was a heavy interdependence between programs and data.
2. **Data Inconsistency :** Data Redundancy also leads to data inconsistency, since either the data formats may be inconsistent or data values may no longer agree or both.
3. **Limited data sharing :** There is limited data sharing opportunities with the traditional file oriented system. Each application has its own private file and users have little opportunity to share data outside their own applications. To obtain data from several incompatible files in separate systems will require a major programming effort.
4. **Poor data control :** A file-oriented system being decentralized in nature, there was no centralized control at the data element (field) level. It could be very common for the data field to have multiple names defined by the various departments of an organization and depending on the file it was in. This could lead to different meaning of a data filed in different context, and conversely, same meaning for different fields. This leads to a poor data control, resulting in a big confusion.

5. **Inadequate data manipulation capabilities :** Since file-oriented system do not provide strong connections between data in different files and therefore its data manipulation capability is very limited.

6. **Data Redundancy (or duplication) :** Applications are developed independently in file processing systems leading to unplanned duplicate files. Duplication is wasteful as it requires additional storage space and changes in one file must be made manually in all files. This also results in loss of data integrity. It is also possible that the same data item may have different names in different files, or the same name may be used for different data items in different files.

7. **Atomicity problems :** Atomicity means either all operations of the transactions are reflected properly in the database or none are, i.e., if everything works correctly without any errors, then everything gets committed to the database. If anyone part of the transaction fails, the entire transaction gets rolled back. The funds transfer must be atomic - it must happen in its entire or not at all. It is difficult to ensure atomicity in a conventional file processing system.

8. **Security problems :** The problem of security in file processing is unauthorized person can retrieve, modify, delete, or insert data in file system. But this is not possible in DBMS.

9. **Integrity problems :** The data values stored in the database must satisfy certain types of consistency constraints. Developers enforce these constraints in the system by adding appropriate code in the various application program. When new constraints are added, it is difficult to change the program to enforce them. The problem is compounded when constraints involves several data items for different files.

10. **Program Data Dependence :** File descriptions (physical structure, storage of the data files and records) are defined within each application program that accesses a given file.

11. **Data isolation :** Because data are scattered in various files, and files may be in different formats, writing new application program to retrieve the appropriate data is difficult.

12. **Difficulty in accessing data :** The conventional file processing environments do not allow needed data to be retrieved in a convenient and efficient manner like DBMS. Better data retrieval system must be developed for general use.

13. **Concurrent access anomalies :** In order to improve the overall performance of the system and obtain a faster response time, many systems allow multiple users to update the data simultaneously. In such an environment, interaction of concurrent updates may result in inconsistent data.

Database Approach

The difficulties that arise from using the file-based system have prompted the development of a new approach in managing large amounts of organizational information called the database approach.

Databases and database technology play an important role in most areas where computers are used, including business, education and medicine. To understand the fundamentals of database systems, we will start by introducing some basic concepts in this area.

Advantage of Database approach over file-based approach : There are several advantages of Database system over file system. Few of them are as follows :

- **No redundant data :** Redundancy removed by data normalization. No data duplication saves storage and improves access time.
- **Data Consistency :** As we discussed earlier the root cause of data inconsistency is data redundancy, since data normalization takes care of the data redundancy, data inconsistency also been taken care of as part of it.
- **Data integrity :** There may be cases when some constraints need to be applied on the data before inserting it in database. The file system does not provide any procedure to check these constraints automatically. Whereas DBMS maintains data integrity by enforcing user defined constraints on data by itself.
- **Data concurrency :** Concurrent access to data means more than one user is accessing the same data at the same time. Anomalies occur when changes made by one user gets lost because of changes made by other user. File system does not provide any procedure to stop anomalies. Whereas DBMS provides a locking system to stop anomalies to occur.
- **Data searching :** For every search operation performed on file system, a different application program has to be written. While DBMS provides inbuilt searching operations. Users only have to write a small query to retrieve data from database.

- **Data Security :** It is easier to apply access constraints in database systems so that only authorized user is able to access the data. Each user has a different set of access thus data is secured from the issues such as identity theft, data leaks and misuse of data.
- **Data sharing :** File system does not allow sharing of data or sharing is too complex. Whereas in DBMS, data can be shared easily due to centralized system.
- **Privacy :** Limited access means privacy of data.
- **Easy access to data :** Database systems manages data in such a way so that the data is easily accessible with fast response times.
- **Easy recovery :** Since a database system keeps the backup of data, it is easier to do a full recovery of data in case of a failure.
- **Flexible :** Database systems are more flexible than file processing systems.

The Evolution of Database systems are as follows :

1. File Management System
2. Hierarchical database System
3. Network Database System
4. Relational Database System

File Management System : The file management system also called as FMS in short is one in which all data is stored on a single large file. The main disadvantage in this system is searching a record or data takes a long time. This lead to the introduction of the concept, of indexing in this system. Then also the FMS system had lot of drawbacks to name a few like updating or modifications to the data cannot be handled easily, sorting the records took long time and so on. All these drawbacks led to the introduction of the Hierarchical Database System.

Hierarchical Database System : The previous system FMS drawback of accessing records and sorting records which took a long time was removed in this by the introduction of parent-child relationship between records in database. The origin of the data is called the root from which several branches have data at different levels and the last level is called the leaf. The main drawback in this was if there is any modification or addition made to the structure then the whole structure needed alteration which made the task a tedious one. In order to avoid this next system took its origin which is called as the Network Database System.

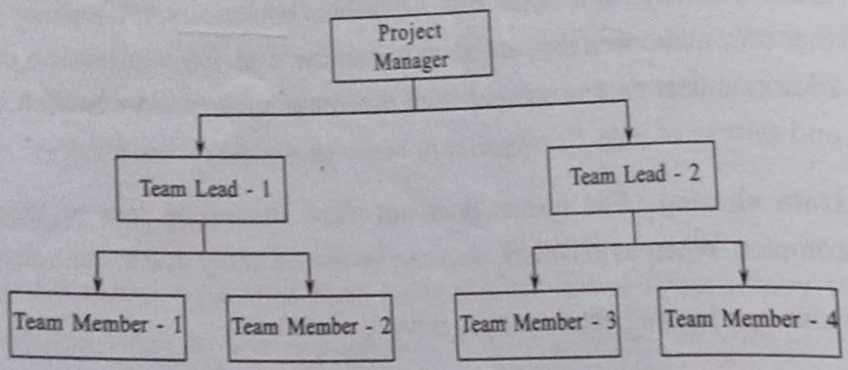


FIG 1.5 : Example of Hierarchical Database System

Network Database System : In this the main concept of many-many relationships got introduced. But this also followed the same technology of pointers to define relationships with a difference in this made in the introduction if grouping of data items as sets.

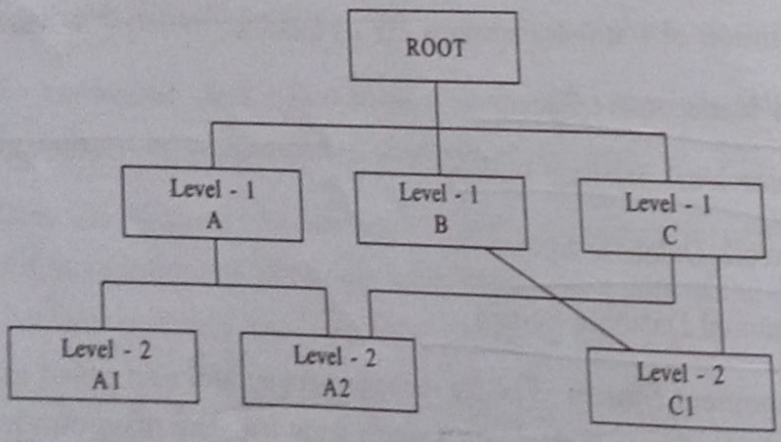


FIG 1.6 : Example of Network Database System

Relational Database System : In order to overcome all the drawbacks of the previous systems, the Relational Database System got introduced in which data get organized as tables and each record forms a row with many fields or attributes in it. Relationships between tables are also formed in this system.

Name	FName	City	Age	Salary
Smith	John	3	35	$280
DOE	Jane	1	28	$325
Brown	Scott	3	41	$265
Howard	Shemp	4	48	$359
Taylor	Tom	2	22	$250

Why DBMS : As the traditional file system cannot handle all the functionality so we are moving to DBMS.

What is DBMS : Data base management system is a software package designed to store and manage data base. Managing data is called manipulation this manipulation includes.

1. Adding a new data

   Ex : Adding details of new student

2. Deleting unwanted data

   Ex : Deleting details of students who finished the course.

3. Changing existing data

   Ex : Modifying the files paid by the students

Function of DBMS :

- It provides various functions like managing large quantity of structured data and efficient retrival and manipulation of data.
- Sharing data that is multiple users can use the data and manipulate the data
- Maintaining data integrity.

What is data integrity :

It ensures that data entered into the database is accurate, valid and reliable.

In short integrity is used to ensure accuracy.

Data Security :

- Data Independence
- Data recovery

Advantages of DBMS :

- It is good for large organisation
- Greater flexibility
- Greater processing power
- Fills the needs of many medium to large organisation.
- Storage for all relevant data.

- Ensure data integrity by managing transctions
- Support multiple access.
- Enforce desgined criteria in relation to data format and structure.
- Providing backup and recovery control
- Advance security.

Disadvantages of DBMS :

- It is expansive or costly
- Packaged separately from operating system.
- Difficult to learn.
- Required skilled administrators.

1.3 CHARACTERISTICS OF THE DATABASE APPROACH

There are a number of characteristics that distinguish the database approach from the file-based system approach.

Self-describing nature of a database system :

A database system is referred to as self-describing because it not only contains the database itself, but also metadata which defines and describes the data and relationships between tables in the database. This information is used by the DBMS software or database users if needed. This separation of data and information about the data makes a database system totally different from the traditional file-based system in which the data definition is part of the application programs.

Insulation between program and data :

In the file-based system, the structure of the data files is defined in the application programs so if a user wants to change the structure of a file, all the programs that access that file might need to be changed as well.

On the other hand, in the database approach, the data structure is stored in the system catalogue and not in the programs. Therefore, one change is all that is needed to change the structure of a file. This insulation between the programs and data is also called program-data independence.

Support for multiple views of data :

A database supports multiple views of data. A view is a subset of the database, which is defined and dedicated for particular users of the system. Multiple users in the system might have different views of the system. Each view might contain only the data of interest to a user or group of users.

Sharing of data and multiuser system

Current database systems are designed for multiple users. That is, they allow many users to access the same database at the same time. This access is achieved through features called concurrency control strategies. These strategies ensure that the data accessed are always correct and that data integrity is maintained.

The design of modern multiuser database systems is a great improvement from those in the past which restricted usage to one person at a time.

Control of data redundancy

In the database approach, ideally, each data item is stored in only one place in the database. In some cases, data redundancy still exists to improve system performance, but such redundancy is controlled by application programming and kept to minimum by introducing as little redundancy as possible when designing the database.

Data sharing

The integration of all the data, for an organization, within a database system has many advantages. First, it allows for data sharing among employees and others who have access to the system. Second, it gives users the ability to generate more information from a given amount of data than would be possible without the integration.

Enforcement of integrity constraints

Database management systems must provide the ability to define and enforce certain constraints to ensure that users enter valid information and maintain data integrity. A database constraint is a restriction or rule that dictates what can be entered or edited in a table such as a postal code using a certain format or adding a valid city in the City field.

There are many types of database constraints. Data type, for example, determines the sort of data permitted in a field, for example numbers only. Data uniqueness such as the primary key ensures that no duplicates are entered. Constraints can be simple (field based) or complex (programming).

Restriction of unauthorized access

Not all users of a database system will have the same accessing privileges. For example, one user might have read-only access (i.e., the ability to read a file but not make changes), while another might have read and write privileges, which is the ability to both read and modify a file. For this reason, a database management system should provide a security subsystem to create and control different types of user accounts and restrict unauthorized access.

Data independence

Another advantage of a database management system is how it allows for data independence. In other words, the system data descriptions or data describing data (metadata) are separated from the application programs. This is possible because changes to the data structure are handled by the database management system and are not embedded in the program itself.

Transaction processing

A database management system must include concurrency control subsystems. This feature ensures that data remains consistent and valid during transaction processing even if several users update the same information.

Provision for multiple views of data

By its very nature, a DBMS permits many users to have access to its database either individually or simultaneously. It is not important for users to be aware of how and where the data they access is stored.

Backup and recovery facilities

Backup and recovery are methods that allow you to protect your data from loss. The database system provides a separate process, from that of a network backup, for backing up and recovering data. If a hard drive fails and the database stored on the hard drive is not accessible, the only way to recover the database is from a backup.

If a computer system fails in the middle of a complex update process, the recovery subsystem is responsible for making sure that the database is restored to its original state. These are two more benefits of a database management system.

1.4 APPLICATION OF DBMS

The following are the various kinds of applications/organizations uses databases for their business processing activities in their day-to-day life. They are :

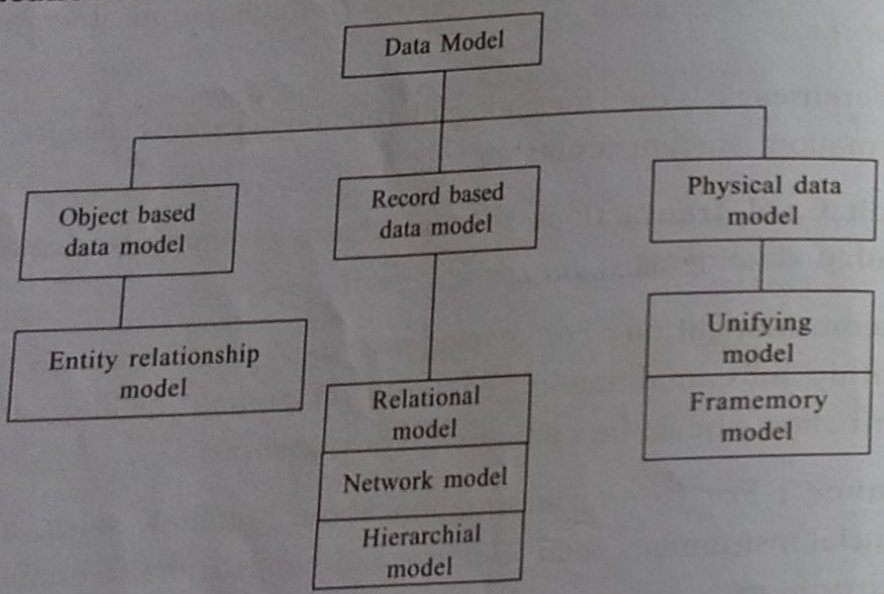
1. **Banking :** It is used for storing customer information, accounts, and loans, and banking transactions.
2. **Airlines :** For reservations and schedule information of tickets, cancelation of tickets, information of flights etc. Airlines were among the first to use databases in a geographically distributed manner-terminals situated around the world accessed the central database system through phone lines and other data networks.
3. **Universities :** It is used for storing information of various colleges, course, student information, student results etc.
4. **Credit Card Transactions :** For purchases on credit cards and generation of monthly statements.
5. **Telecommunication :** For keeping records of customers, calls made, generating monthly bills, maintaining balances on prepaid calling cards, and storing information about the communication networks.
6. **Finance :** For storing information about holdings, sales, and purchases of financial instruments such as stocks and bonds and also enabling online trading of customers.
7. **Sales :** For storing customer product, and purchase information.
8. **Manufacturing :** For management of supply chain and for tracking production of items in factories, inventories of items in warehouses/stores, and orders for items.
9. **Online retailer :** For sales data done by online order, tracking the list of items generating bills and maintain online product information.
10. **Human resources :** For information about employees, salaries, payroll taxes and benefits, and for generation of pay cheques.
11. **Railway Reservation Systems :** For reservations and schedule information.
12. **Web :** For access the Back accounts and to get the balance amount.
13. **E-Commerce :** For Buying a book or music CD and browse for things like watches, mobiles from the Internet.

1.5 DATA MODELS

It is the collection of concepts that can be used to describe structure of database.

- It includes the set of basic operations for specifying, retrieval and updates on database, and also allows the data base designer to specify a set of valid user defined operations.
- Data model is a collection of tools for describing data, data relationship, data sematics and data constraints.

Classification of Data Model :



1. Object based data model :

- It describes data at conceptual level and view level.
- It provides flexible structure.

Entity Relationship Model (ER Model) :

Entity relationship model is a object based data model.

2. Record based data model :

- Here the data base is structured in fixed format records of several types.
- Each record refines fixed number of fields (attributes) and each field is of fixed length.
- This model specify overall logical structure of database at conceptual level commonly used models are

Relational model

Netowork model

Hierarchial model

3. **Physical data model :**

- It is used to describe the data at lowest level.
- It is a representation of a data design which take care of facilities of a data base
- The commonly used models are unifying model (or) Frame memory used.

(I) **Entity Relationship Model (ER Model) :** It is nothing but a collection of basic objects (entites) and relationship among these objects

Entity : Entity is a distinguishable object. Each entity is associated with set of attributes describing it.

Ex : Bank account number, college, student etc,

Relationship : It is an association among several entities

Ex : Student and branch

Entity Set : It is a set of entities of same type

Ex : Customers of a shop.

ER Model :

The overall logical structure of a database can be represented graphically by ER diagram.

The ER diagram is build up from the following components.

Rectangle : Which represents entity self.

Eltipes : Which represents attributes.

Diamonds : Which represents relationship among entity self

Lines : Which link attributes to entity sets and entity sets to relationships.

Double Ellipes : Which represents multivalued attributes.

Dashed Ellipes : Which densite deriver attributes.

Double Lines : Which represents total partiipaty of an enity in a relationship it.

Double rectangle : Which represent weak entity sets.

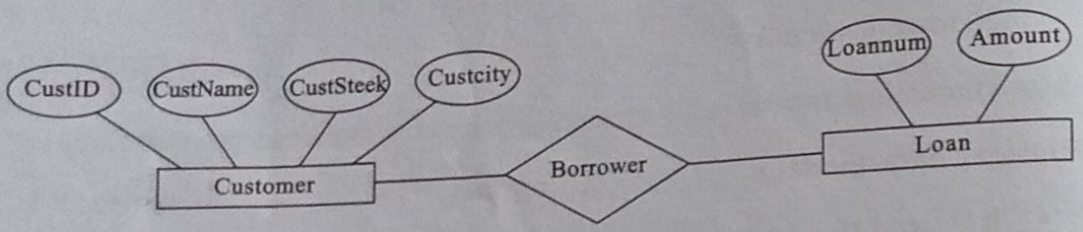


FIG 1.7 : Example of Customer-Borrower-Loan ER MOdel

(II) Hierarchial Data Model :

- It uses Tree structure to represent relationship among records.
- Each record is collection of fields which contain one data value.
- Records are connected with each other through a list.

A link is association between two records.

Features of Hierarchial Model :

- Each tree can have only one root record and this record does not have paren record.
- Root can have any number of child records child record can have one paren record.

Advantages :

- It allows one - to - one and one-to-many relationships.
- It handles large amount of data.

Disadvantages :

- Easy to design but complex to implement.
- Duplication of data takes place which leads to wastage of space.
- Updation of data leads to data in consistency.
- Does not allow many-to-many relationships.

Diagramatic Representation of Hieranchial Model

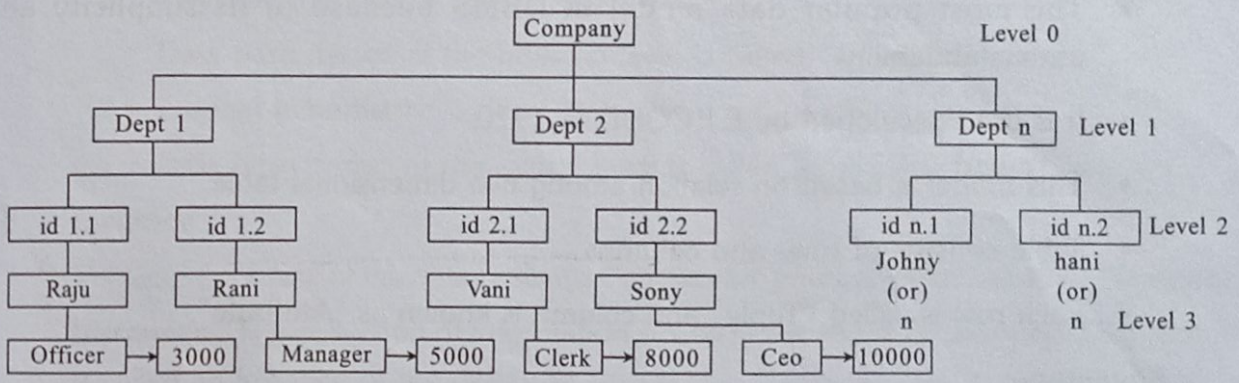


FIG 1.8 : Example of Company Hierarchial Model

(III) Network Model :

- It replaces Hierarchial tree with a graph
- Here records have more than one parent.
- Many-to-many relationship is possible
- Relationship among data is represented by pointers.

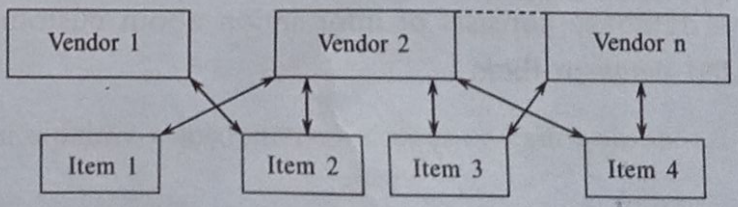
Advantages :

- Many-to-many relationship is possible
- Storage space is reduced, which leads to less data redundancy.
- Provide faster access of data.
- Data accessing is flexible

Disadvantages :

- Difficult to design and use.
- Difficult to make changes in database.
- It is not user friendly as it has complex structure.

Diagramatic Representation of Network Model :



(IV) Relational Model :

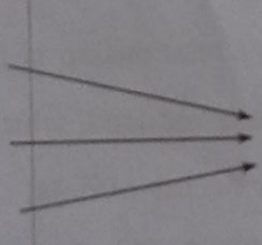
- The most popular data model in DBMS because of its simplicity and understandability.
- It is used/developed by E.F.CODD in 1970.
- This model is based on relation among two dimensional table.
- Table consists of rows and columns
- Each row is called "Tuple" and column is known as "Attribute".

Advantages :

- It allows many-to-many relationship
- Data reduandancy is controled
- Structures are very simple and easy to build.
- Faster access of data.
- Storage space required is reduced

Student

PIN	Name
18001-(M-201	Rani
18001-(M-202	Vani
18001-(M-203	Nani



Here
PIN, Name → Attributes
Student → Relation Name
tuples

1.6 INSTANCE AND SCHEMA

It is similar to types and variable in programming language.

Schema :

- The logical structure of data base is called ***"Schema"***.

  Ex : The database consists of information about customers, accounts and relationship between them.

- Schema is ***"analogous"*** to type information of a variable in a program.

Types of Schema :

1. **Physical schema :**

   Data base design at the physical level is called ***"Physical schema"***.

2. **Logical schema :**

   Data base design at the logical level is called ***"logical schema"***.

Instance :

The actual content of the data base at a ***"particular point of time"*** is called ***"Instance"***.

Instances : The collection of information stored in the database at a particular moment is called an instance of the database.

Schemas : The overall design of the database is called the database schema. That is, the description of a database is called the database schema which is specified during database design and is not expected to change frequently.

1.7 THREE SCHEMA ARCHITECTURE

Databases are characterized by three-schema architecture because there are three different ways to look at them. Each schema is important to different groups in an organization. The Figure below illustrates this architecture and the groups most involved with each schema.

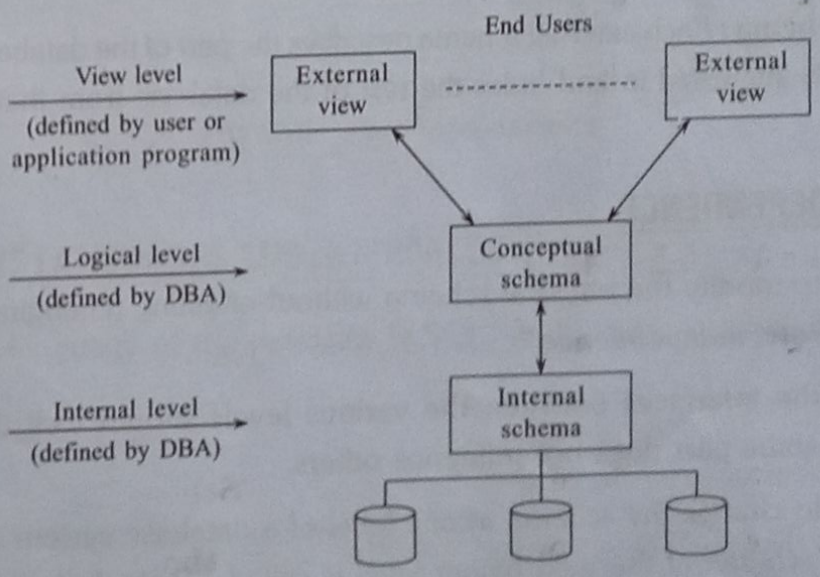


FIG 1.9 : Three Schema Architecture

The database schema can be partitioned according to the level of abstraction.

(a) **Physical or Internal Schema :** The physical schema, describes the physical storage structure of the database. Internal level is concerned with the following activities :

1. Storage space allocation for data and storage.
2. Record descriptions for storage with stored size for data items.
3. Record Placement.
4. Data compression and data encryption techniques.

This schema uses a physical data model and describes the complete details of data storage and access path for the database.

(b) **The conceptual or logical schema :** The logical schema describes the structure of the whole database for a community of users.

The conceptual schema describes the entities, data types, relationships, user operations and constraints and hides the details of physical storage structure.

The conceptual level is concerned with the following activities :

(i) All entities, their attributes and their relationships.

(ii) Constraint on the data.

(iii) Semantic information about the data.

(iv) Security information.

(v) Checks to retain data consistency and integrity.

(c) **External Schema :** 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.

1.8 DATA INDEPENDENCE

- The ability to modify the physical schema without effecting (changing) logical schema is called ***"Data independence"***.
- In general the interfaces between the various levels should well defined such that changes in some part does not influence others.

The ability to change the schema at one level of a database system without having to change the schema at the next higher level is called ***"Data Independence".***

There are two types of data independence :

1. **Physical Data Independence :** Physical data Independence is the ability to change the internal schema without having to change the conceptual schema.

Ex : By creating additional access structure to improve the performance of the retrieval or update.

2. **Logical Data Independence :** The logical Data Independence is the ability to change the conceptual schema without having to change application programs (external schema).

Ex : We may change the conceptual schema to expand the database by adding a record types or data items. (or) to reduce the database by removing data item.

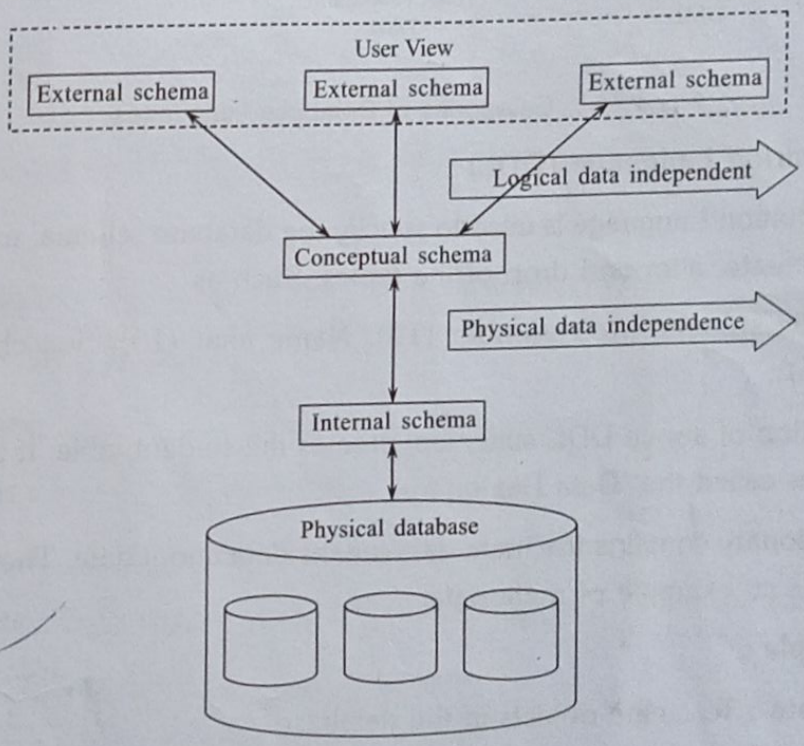


FIG 1.10 : Data Independence

1.9 DATABASE LANGUAGES AND INTERFACES

The normal language of the database is SQL. A database system provides following types of

Languages :

- Data Definition Language (DDL)
- Data Manipulation Language (DML)
- Data Control Language (DCL)
- Data Query Language (DQL)

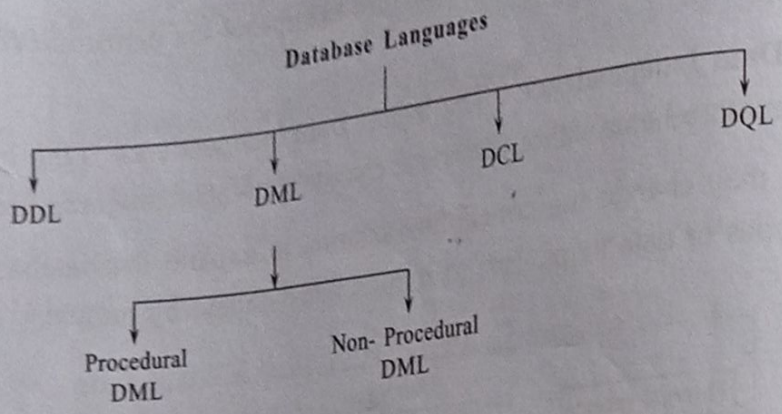


FIG 1.11 : Categories of Database Languages

Data Definition Language (DDL) :

A Data Definition Language is used to specify the database schema. e.g., The example of DDL is create, alter and drop of the tables. Such as

Create table student (Roll number (10), Name char (15), Sex char (2), Address varchar(15));

The execution of above DDL statement creates the student table. It updates a special set of tables called the 'Data Dictionary'.

A data dictionary contains the meta data means data about data. The schema (design) of a table is an example of meta data.

For Example :

(i) **Create :** To create objects in the database.

(ii) **Alter :** Alters the structure of the database.

(iii) **Drop :** Delete the objects from the data.

(iv) **Truncate :** Remove all records from a table, including all spaces allocated for the records are removed.

(v) **Comment :** Add comments to the data dictionary.

Data-Manipulation Language (DML)

Data Manipulation means :

- The retrieval of data from the database.
- The deletion of the data from the database
- The insertion of the new data into the database
- The modification of data in the database.

DML is a language that enables users to access or modify the data from the database.

DML is basically two types :

(i) Procedural DML

(ii) Non procedural DML

Procedural DML : Procedural DMLs require a user to specify what Data are needed and how to get those data.

e.g., PL/SQL

Non Procedural DML : Non procedural DMLs require a user to specify what data are needed without specifying how to get those data.

e.g., SQL

(i) Select Roll, Name, Address from Student Where Roll = 3;

(ii) Select * from student :

For example,

(i) Insert : Insert data into a table.

(ii) Update : Updates existing data within a table.

(iii) Delete : Deletes all records from a table, the space for the records remain.

(iv) Lock Table : Control concurrency.

Data Control Language (DCL)

It is the components of SOL statements that control access to data and to the database.

For example,

(i) Commit : Save work done.

(ii) Roll-Back : Restore database to original since the last commit.

(iii) Save Point : Identify a point in a transaction to which you can later roll back.

(iv) Grant/Revoke : Grant or take back permissions to or from the oracle users.

(v) Set Transaction : Change or take back permissions to or from the oracle users.

Data Query Language (DQL)

It is the component of SQL statement that allows getting data from the database and imposing ordering upon it.

Note : DDL and DML are not two different languages it is the part of SQL.

SQL
- DDL (create the table)
- DML (manipulate the table)

Query : A query is a statement requesting the retrieval of information.

DBMS Interfaces :

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

Menu-Based interfaces for Browsing : They are often used in browsing interfaces, which allow a user to look through the contents of a database in an exploratory and unstructured manner.

Forms-Based Interfaces : A form-based interface displays a form to each user.

Graphical-User Interfaces : A graphical interface displays a schema to the user in diagrammatic form.

Natural Language Interfaces : It has its own *"schema"* which is similar to the data base conceptual schema.

Interface for DBA.

Interface for User.

1.10 THE DATABASE SYSTEM ENVIRONMENT

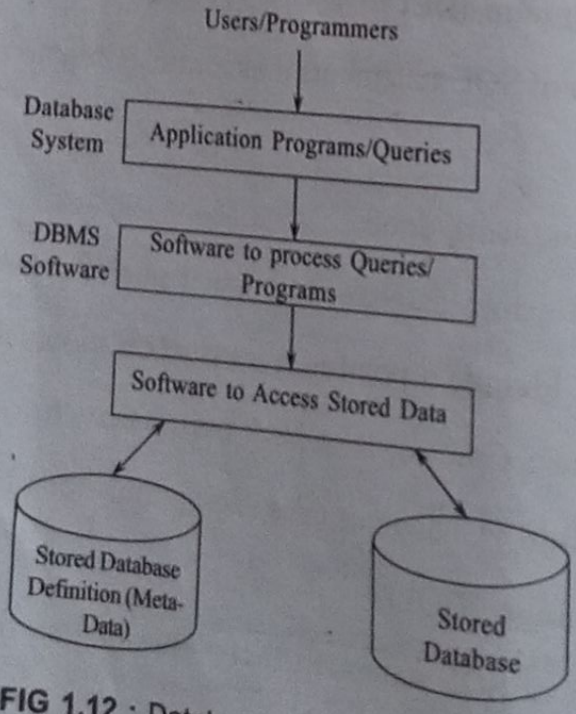


FIG 1.12 : Database system environment

One of the major aims of a database is to supply users with an abstract view of data, hiding certain elements like how the data is stored and manipulated. So, the starting point for the design of a database must be an abstract and general description of the information requirements of the organization that is to be represented in the database. And hence you will require an environment to store data and make it work as a database.

A database environment is a collective system of components that comprise and regulates the group of data, management, and use of data which consist of software, hardware, people, techniques of handling database and the data also.

Here, the hardware in a database environment means the computers and computer peripherals that are being used to manage a database and the software means the whole thing right from the operating system (OS) to the application programs that includes database management software like M.S. Access or SQL Server. Again the people in a database environment include those people who administrate and use the system. The techniques are the rules, concepts, and instructions given to both the people and the software along with the data with the group of facts and information positioned within the database environment.

DBMS Components :

1. **Stored Data Manager**
   - The database and the database catalogue are stored on disk
   - Access to the disk is handled by the Operating System.
   - A higher-level stored data manager controls access to DBMS information that is stored on disk, whether part of the database or the catalogue.
   - The stored data manager may use basic OS services for carrying out low-level data transfer, such as handling buffers.
   - Once data is in buffers, the other DBMS modules, as well as other application programs can process it.
2. **DDL Compiler**
   - Processes the schema definitions and stores the descriptions (meta-data) in the catalogue.
3. **Runtime Database Processor**
   - Handles database access at runtime.
   - Received retrieval or update operations and carries them out on the database.
   - Access to the disk goes through the stored data manager.

4. **Query Compiler**
   - Handles high-level queries entered interactively.
   - Parses, analyzes and interprets a query, then generates calls to the runtime processor for execution.

5. **Precompiler**
   - Extracts DML commands from an application program written in a host language.
   - Commands are sent to DML compiler for compilation into code for database access. The rest is sent to the host language compiler.

6. **Client Program**
   - Accesses the DBMS running on a separate computer from the computer on which the database resides. It is called the client computer, and the other is the database server. In some cases a middle level is called the application server.

7. **Database System Utilities :** DBMSs have database utilities that help the DBA manage the system. Functions include
   - Loading - used to load existing text/sequential files into the database. Source format and desired target file are specified to the utility, and the utility reformats the data to load into a table.
   - Backup - creates a backup copy of the database, usually by dumping database onto tape. Can be used to restore the database in case of failure. Incremental backup can be used which records only the changes since the last backup.
   - File Reorganization - reorganize database files into different file organizations to improve performance.
   - Performance Monitoring - monitors database usage and provides statistics to the DBA. DBA uses the statistics for decision-making.

8. **Tools, Environments and Communication Facilities :**
   - CASE Tools - used in the design phase to help speed up the development process.
   - Data dictionary system - stores catalog information about schemas and constraints, as well as design decisions, usage standards, application program descriptions, user information. Also called an information repository. Can be accesses directly by DBA or users when needed.

- Application development environments - (i.e. JBuilder) provide environment for developing database applications, and include facilities to help in database design, GUI development, querying and updating and application development.
- Communication software - allow users at remote locations to access the database through computer terminals, workstations or personal computers. Connected to the database through data communications hardware such as phone lines, local area networks etc.

1.11 CENTRALIZED AND CLIENT SERVER ARCHITECTURES FOR DBMS

1. Centralized DBMS Architecture

- Used mainframes to provide main processing for user application programs, user interface programs and DBMS functionality
- User accessed systems via 'dumb' computer terminals that only provided display capabilities, with no processing capabilities.
- All processing was performed remotely on the computer system, and only display information was sent to the terminals, connected via a network.
- Dumb terminals were replaces with workstations, which lead to the client/server architecture.

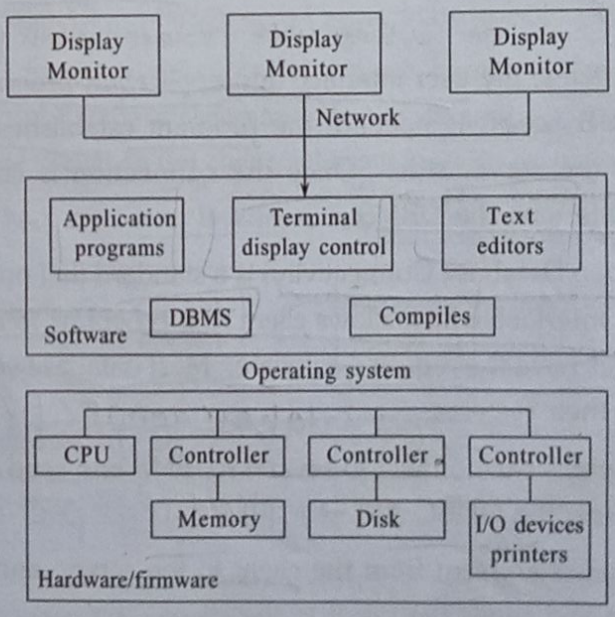


FIG 1.13 : Centralized DBMS Architecture

2. Client Server Architecture :

- Define specialized servers with specific functionalities (file servers, print servers, web servers, database servers)
- Many client machines can access resources provided by specialized server.
- Client machines provide user with the appropriate interfaces to utilize servers, as well as with local processing power to run local applications.
- Some machines are client sites, with client software installed and other machines are dedicated servers.
- Client - a user machine that provides user interface capabilities and local processing.
- Server - machine that provides services to client machines such as file access, printing, and database access.

3. Two Tier Client/Server Architecture for DBMSs

- In relational DBMSs, user interfaces and application programs were first moved to the client side.
- SQL provided a standard language, which was a logical dividing point between client and server.
- Query and transaction functionality remained on server side. In this architecture, the server is called a query server, or transaction server.
- In relational DBMSs, the server is called an SQL server, because most RDBMSs use SQL.
- In such systems, the user interface and application programs run on the client, when DMBS access is needed, the program establishes a connection to the DBMS on the server side. Once the connection is created, the client can communicate with the DBMS.
- ODBC (Open Database Connectivity) is a standard that provides and application processing interface which allows client side programs to call the DBMS as long as both sides have the required software. Most database vendors provide ODBC drivers for their systems.
- Client programs can connect to several RDBMS and send query and transaction requests using the ODBC API.
- Query requests are sent from the client to the server, and the server processes the request and sends the result to the client.
- A related Java standard is JDBC, which allows Java programs to access the DBMS through a standard interface.

- These systems are called two tier architectures because the software components are distributed over two systems, the client and server.

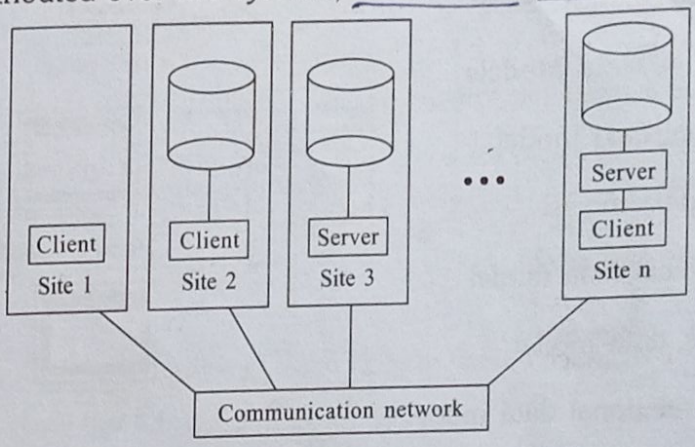


FIG 1.14 : Two-Tier Client Server Architecture

4. Three-Tier Client Server Architecture for Web Applications

- Many web applications use three-tier architecture, which adds an intermediate layer between the client and the database server.
- The middle tier is called the application server, or the web server. Plays an intermediate role, by storing business rules (procedures/constraints) used to access data from database.
- Can improve database security by checking the clients credentials before forwarding request to database server.
- Clients contain GUI interfaces and application specific rules.
- The intermediate server accepts the requests from the client, processes the request and sends the database commands to the db server, then passes the data from the database server to the client, where it may be processes further and filtered.
- The three tiers are : user interface, application rules, and data access.

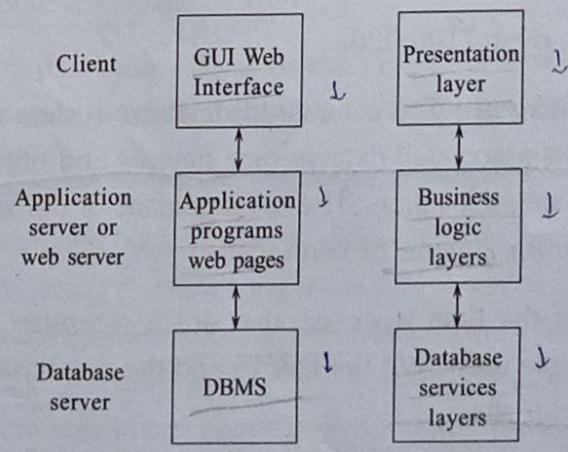


FIG 1.14 : Three-Tier Client Server Architecture

1.12 CLASSIFICATION OF DBMS

1. **On the basis of Data Models**
   - Relational data model
   - Object data model
   - Hierarchical data model
   - Network data model
   - Object relational data model
2. **On the basis of Number of Users**
   - Single User systems
   - Multi User systems
3. **On the basis of the site location**
   - Centralised - data is stored at single site.
   - Distributed- database and DBMS software stored over many sites connected by network
   - Parallel
   - Homogeneous - use same DBMS software at multiple sites.
4. **Cost**
   - Low-end systems under $3000.
   - High-end systems, over $100,000.

Centralised Database System : The centralised database system consists of a single processor together with its associated data storage devices and other peripherals. It is physically confined to a single location. The management of the system and its data are controlled centrally form anyone or central site.

A DBMS is centralised if the data is stored at a single computer site. A centralised DBMS can support multiple users, but the DBMS and the database themselves reside totally at a single computer site.

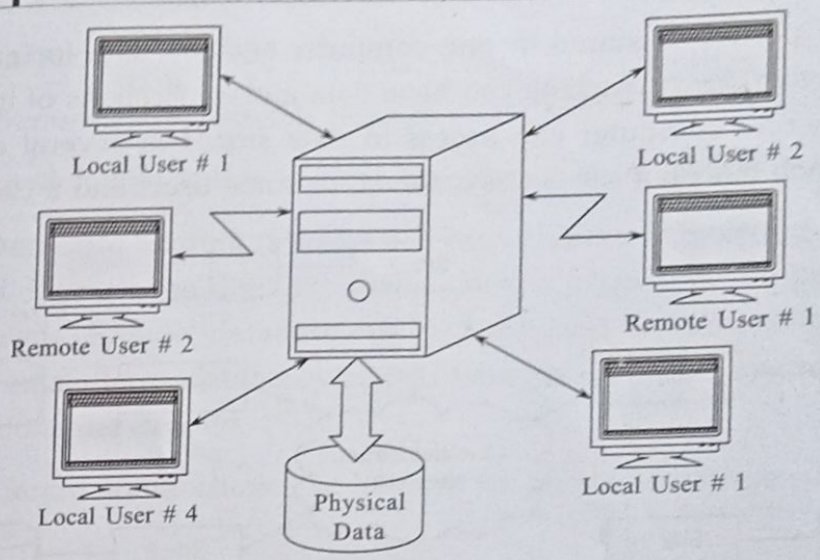


FIG 1.15 : Centralised Database System

Advantages of Centralised Database System :

Most of the functions such as update, backup, query, control access and so on, are easier to accomplish in a centralised database system.

- The size of the database and the computer on which it reside need not have any bearing on whether the database is centrally located.

Disadvantages :

- When the central site computer or database system goes down, then every users is blocked from using the system until the system comes back.
- Communication costs from the terminals to the central site can be expensive.

Distributed Database System :

A distributed database is a collection of multiple logically interrelated database distributed over a Computer Network.

A distributed database management system is a software system that manages a distributed database while making the distribution transparent to the user.

In distributed database system, data is distributed across a variety of different databases.

These are managed by a variety of different DBMS softwares running on a variety of different computing machines supported by a variety of different operating systems. These machines are distributed geographically and connected together by a variety of communication networks. In distributed database system, one application can operate on data that is distributed geographically on different machines. Thus, in distributed databse system, the data might be distributed on different computers in such a way that

data for one portion is stored in one computer and the data for another portion is stored in another. Each machine can have data and applications of its own. However, the users on one computer can access to data stored in several other computers. Therefore, each machine will act as a server for some users and a client for others.

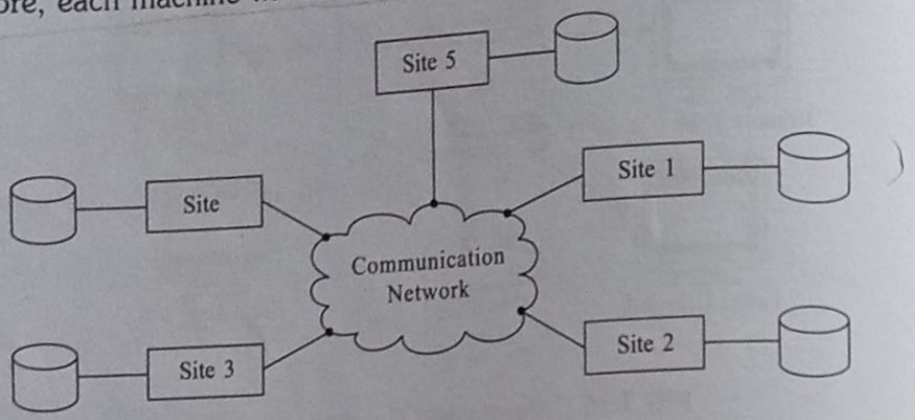


FIG 1.16 : Distributed Database System

Advantages of Distributed Database :

1. Management of distributed data with different level of transparency.
2. Increased Reliability and Availability.
3. Distributed query processing.
4. Improved the performance.
5. Improved scalability
6. Parallel evaluation.
7. Distributed database recovery.
8. Replicated Data management
9. Security
10. Network transparency.
11. It provides greater efficiency and better performance.
12. Replication transparency.

Disadvantages of Distributed Database :

1. Technical problem of connecting dissimilar machine.
2. Software cost and complexity.
3. Difficulty in data integrity control.

4. Processing overhead.
5. Communication network failures.
6. Recovery from failure is more complex.

Parallel Database System : Parallel database systems architecture consists of a multiple CPUs and data storage disks in parallel. Hence, they improve processing and input/output speeds. Parallel database systems are used in the applications that have to query extremely large databases or that have to process an extremely large number of transactions per second.

Several different architectures can be used for parallel database systems, which are as follows :

- **Shared Memory :** All the processors share a common memory.
- **Shared Data Storage Disk :** All the processors share a common set of disks. Shared disk systems are sometimes called clusters.
- **Independent Resources :** The processors share neither a common memory nor common disk.
- **Hierarchical :** This model is a hybrid of the preceding three architectures.

Fig. illustrates the different architecture of parallel database system.

In shared data storage disk, all the processors share common disk (or set of disks), as shown in below Fig. 1.17.

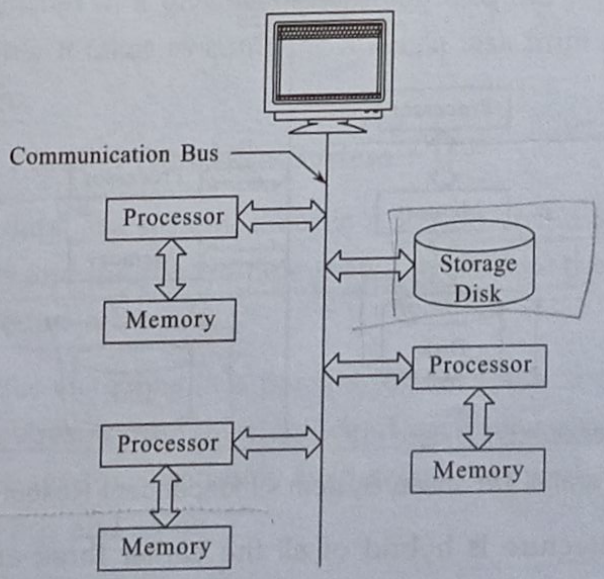


FIG 1.17 : Parallel Database System - Shared Data Storage Disk

In shared memory architecture, all the processors share common memory, as shown in below Fig. 1.18.

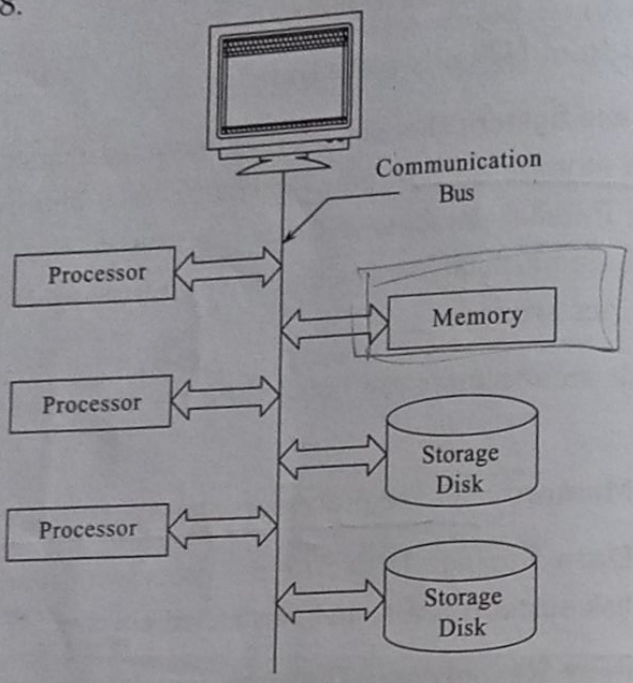


FIG 1.18 : Parallel Database System - Shared Memory Architecture

In independent resource architecture, the processors share neither a common memory nor a common disk. They have their own independent resources as shown in below Fig. 1.19.

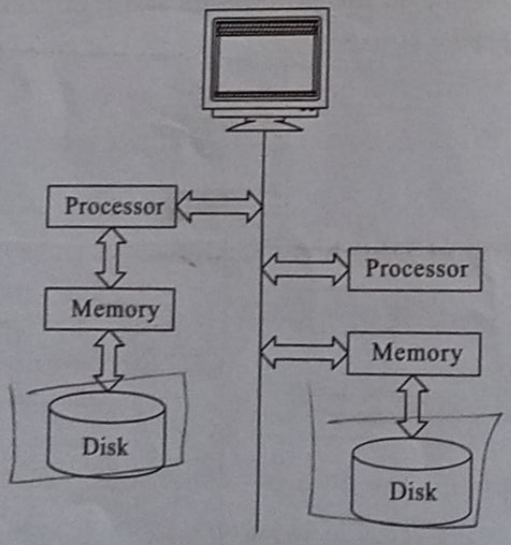


FIG 1.19 : Parallel Database System - Independent Resource Architecture

Hierarchical architecture is hybrid of all the earlier three architectures, as shown in below Fig. 1.20.

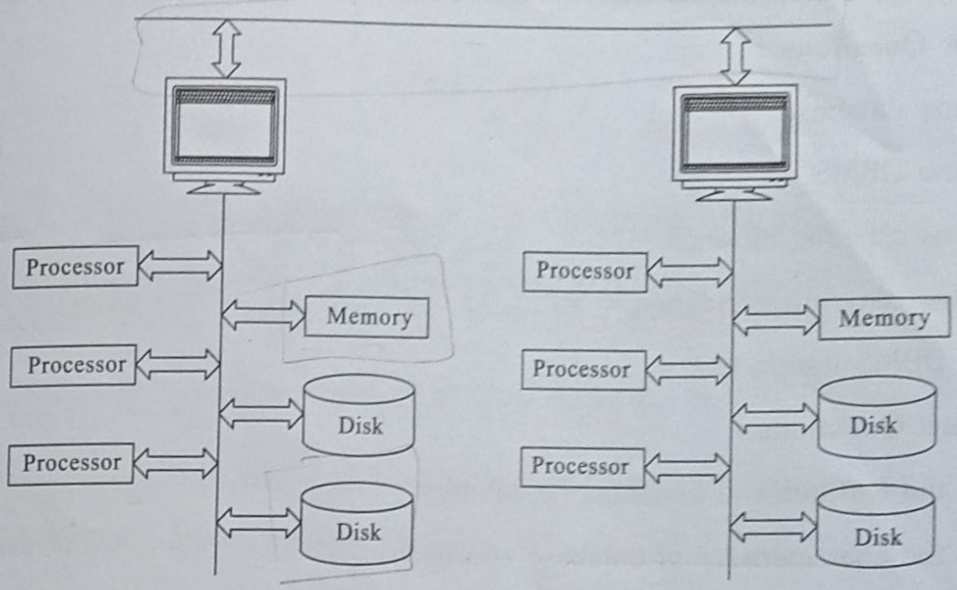


FIG 1.20 : Parallel Database System - Hierarchical Architecture

Advantages of Parallel Database System :

1. Parallel database systems are very useful for the applications that have to query extremely large database or that have to process an extremely large number of transactions per second.
2. This techniques used to speed-up transaction processing on data-server systems.
3. In a parallel database systems, the through put (that is, the number of tasks that can be completed in a given time interval) and the response time (that is, the amount of time it takes to complete a single task from the time it is submitted) are very high.

Disadvantages of Parallel Database System :

1. In a parallel database system, there is a startup cost associated with initiating a single process and the startup-time may overshadow the actual processing time, affecting speedup adversely.
2. Since processes executing in a parallel system often access shared resources, a slowdown may result from interference of each new process as it competes with existing processes for commonly held resources, such as shared data storage disks, system bus and so on.

REVIEW QUESTIONS

One Mark Questions :

1. Define database.
2. Define DBMS.
3. Define schema, instance.
4. Define data independence.
5. List DBMS interfaces.

Three Mark Questions :

1. List the features and benefits of databases.
2. List the characteristics of database approach.
3. Describe the types of models.
4. Discuss the applications of DBMS.
5. Draw the three schema architecture.
6. Describe database environment.
7. Write about different database languages.

Five Mark Questions :

1. Illustrate the characteristics of database approach.
2. Explain different types of DataModels.
3. Illustrate the evolution of DBMS.
4. Explain centralized and Client/Server architectures for DBMS.
5. Classify the different types of Database Management Systems.