Data : Data is nothing but facts and statistics stored or free flowing over a network, generally it's raw and unprocessed. For example: When you visit any website, they might store you IP address, that is data, in return they might add a cookie in your browser, marking you that you visited the website, that is data, your name, it's data, your age, it's data.

Data becomes **information** when it is processed, turning it into something meaningful. Like, based on the cookie data saved on user's browser, if a website can analyse that generally men of age 20-25 visit us more,

What is a Database?

A **Database** is a collection of related data organised in a way that data can be easily accessed, managed and updated. Database can be software based or hardware based, with one sole purpose, storing data.

What is DBMS?

A **DBMS** is a software that allows creation, definition and manipulation of database, allowing users to store, process and analyse data easily. DBMS provides us with an interface or a tool, to perform various operations like creating database, storing data in it, updating data, creating tables in the database and a lot more.

DBMS also provides protection and security to the databases. It also maintains data consistency in case of multiple users.

Here are some examples of popular DBMS used these days:

- MySql
- Oracle
- SQL Server
- IBM DB2
- PostgreSQL

Characteristics of Database Management System

A database management system has following characteristics:

- **Data stored into Tables:** Data is never directly stored into the database. Data is stored into tables, created inside the database. DBMS also allows to have relationships between tables which makes the data more meaningful and connected. You can easily understand what type of data is stored where by looking at all the tables created in a database.

- **Reduced Redundancy:** In the modern world hard drives are very cheap, but earlier when hard drives were too expensive, unnecessary repetition of data in database was a big problem. But DBMS follows **Normalisation** which divides the data in such a way that repetition is minimum.

- **Data Consistency:** On Live data, i.e. data that is being continuosly updated and added, maintaining the consistency of data can become a challenge. But DBMS handles it all by itself.

- **Support Multiple user and Concurrent Access:** DBMS allows multiple users to work on it(update, insert, delete data) at the same time and still manages to maintain the data consistency.

- **Query Language:** DBMS provides users with a simple Query language, using which data can be easily fetched, inserted, deleted and updated in a database.

- **Security:** The DBMS also takes care of the security of data, protecting the data from un-authorised access. In a typical DBMS, we can create user accounts with different access permissions, using which we can easily secure our data by restricting user access.

- DBMS supports **transactions**, which allows us to better handle and manage data integrity in real world applications where multi-threading is extensively used.

Advantages of DBMS

- Segregation of applicaion program.

- Minimal data duplicacy or data redundancy.

- Easy retrieval of data using the Query Language.

- Reduced development time and maintainance need.

- With Cloud Datacenters, we now have Database Management Systems capable of storing almost infinite data.
- Seamless integration into the application programming languages which makes it very easier to add a database to almost any application or website.

There are the following differences between DBMS and File systems:

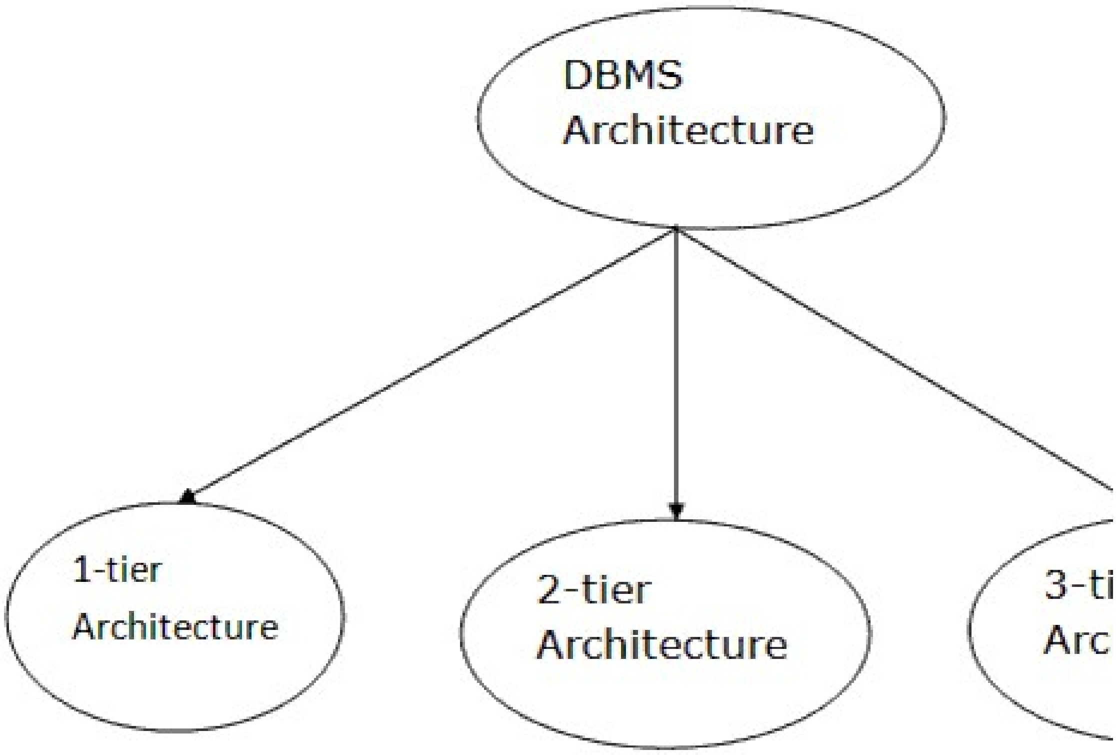
Basis	DBMS Approach	File System Approach
Meaning	DBMS is a collection of data. In DBMS, the user is not required to write the procedures.	The file system is a collection of data. In this system, the user has to write the procedures for managing the database.
Sharing of data	Due to the centralized approach, data sharing is easy.	Data is distributed in many files, and it may be of different formats, so it isn't easy to share data.
Data Abstraction	DBMS gives an abstract view of data that hides the details.	The file system provides the detail of the data representation and storage of data.
Security and Protection	DBMS provides a good protection mechanism.	It isn't easy to protect a file under the file system.
Recovery Mechanism	DBMS provides a crash recovery mechanism, i.e., DBMS protects the user from system failure.	The file system doesn't have a crash mechanism, i.e., if the system crashes while entering some data, then the content of the file will be lost.
Manipulation Techniques	DBMS contains a wide variety of sophisticated techniques to store and retrieve the data.	The file system can't efficiently store and retrieve the data.
Concurrency Problems	DBMS takes care of Concurrent access of data using some form of locking.	In the File system, concurrent access has many problems like redirecting the file while deleting some information or updating some information.

Where to use	Database approach used in large systems which interrelate many files.	File system approach used in large systems which interrelate many files.
Cost	The database system is expensive to design.	The file system approach is cheaper to design.
Data Redundancy and Inconsistency	Due to the centralization of the database, the problems of data redundancy and inconsistency are controlled.	In this, the files and application programs are created by different programmers so that there exists a lot of duplication of data which may lead to inconsistency.
Structure	The database structure is complex to design.	The file system approach has a simple structure.
Data Independence	In this system, Data Independence exists, and it can be of two types. • Logical Data Independence • Physical Data Independence	In the File system approach, there exists no Data Independence.
Integrity Constraints	Integrity Constraints are easy to apply.	Integrity Constraints are difficult to implement in file system.
Data Models	In the database approach, 3 types of data models exist: • Hierarchal data models • Network data models • Relational data models	In the file system approach, there is no concept of data models exists.
Flexibility	Changes are often a necessity to the content of the data stored in any system, and these changes are more easily with a database approach.	The flexibility of the system is less as compared to \the DBMS approach.
Examples	Oracle, SQL Server, Sybase etc.	Cobol, C++ etc.

DBMS Architecture

- The DBMS design depends upon its architecture. The basic client/server architecture is used to deal with a large number of PCs, web servers, database servers and other components that are connected with networks.
- The client/server architecture consists of many PCs and a workstation which are connected via the network.
- DBMS architecture depends upon how users are connected to the database to get their request done.

Types of DBMS Architecture



Database architecture can be seen as a single tier or multi-tier. But logically, database architecture is of two types like: **2-tier architecture** and **3-tier architecture**.

1-Tier Architecture

- In this architecture, the database is directly available to the user. It means the user can directly sit on the DBMS and uses it.
- Any changes done here will directly be done on the database itself. It doesn't provide a handy tool for end users.
- The 1-Tier architecture is used for development of the local application, where programmers can directly communicate with the database for the quick response.

2-Tier Architecture

- The 2-Tier architecture is same as basic client-server. In the two-tier architecture, applications on the client end can directly communicate with the database at the server side. For this interaction, API's like: **ODBC**, **JDBC** are used.
- The user interfaces and application programs are run on the client-side.
- The server side is responsible to provide the functionalities like: query processing and transaction management.
- To communicate with the DBMS, client-side application establishes a connection with the server side.

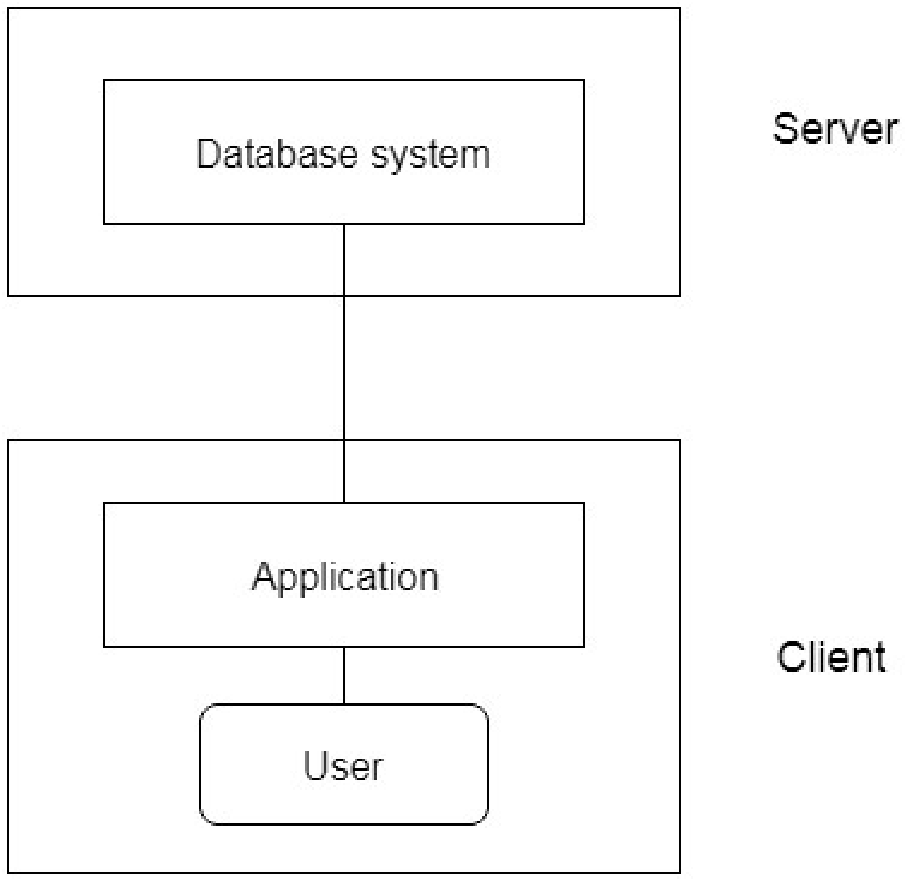


Fig: 2-tier Architecture

3-Tier Architecture

- The 3-Tier architecture contains another layer between the client and server. In this architecture, client can't directly communicate with the server.
- The application on the client-end interacts with an application server which further communicates with the database system.
- End user has no idea about the existence of the database beyond the application server. The database also has no idea about any other user beyond the application.
- The 3-Tier architecture is used in case of large web application.

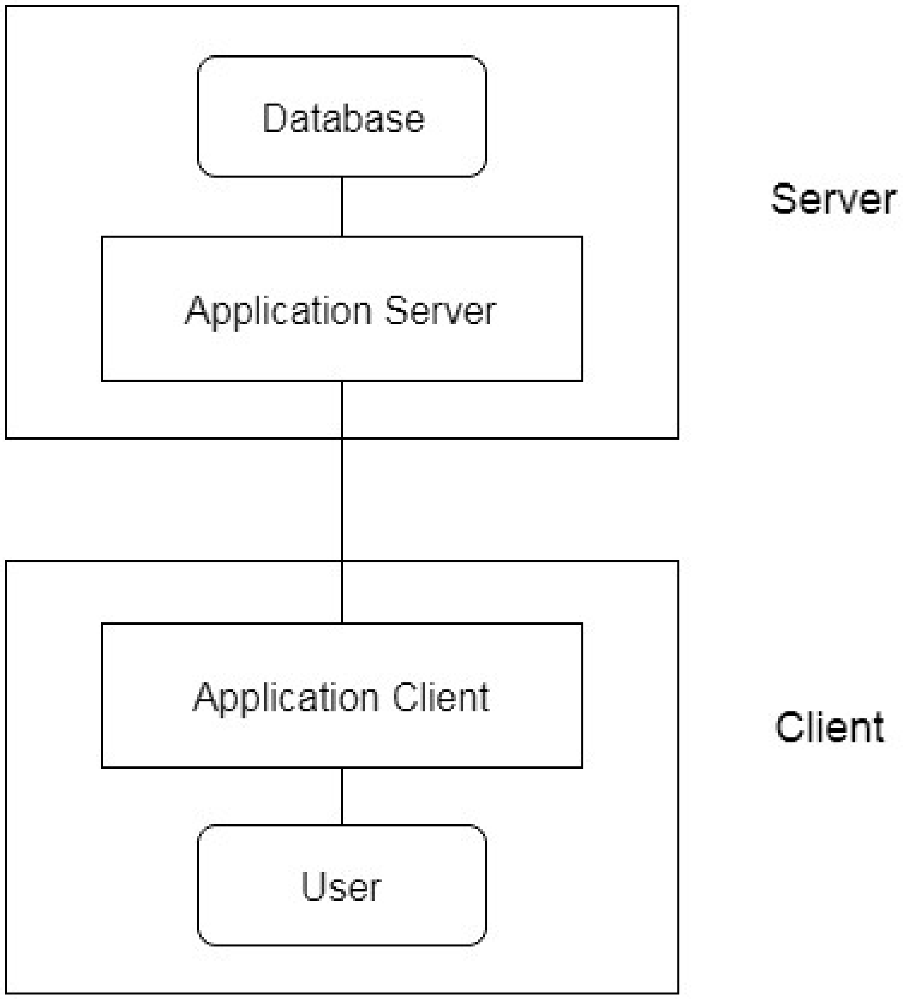


Fig: 3-tier Architecture

Data model Schema and Instance

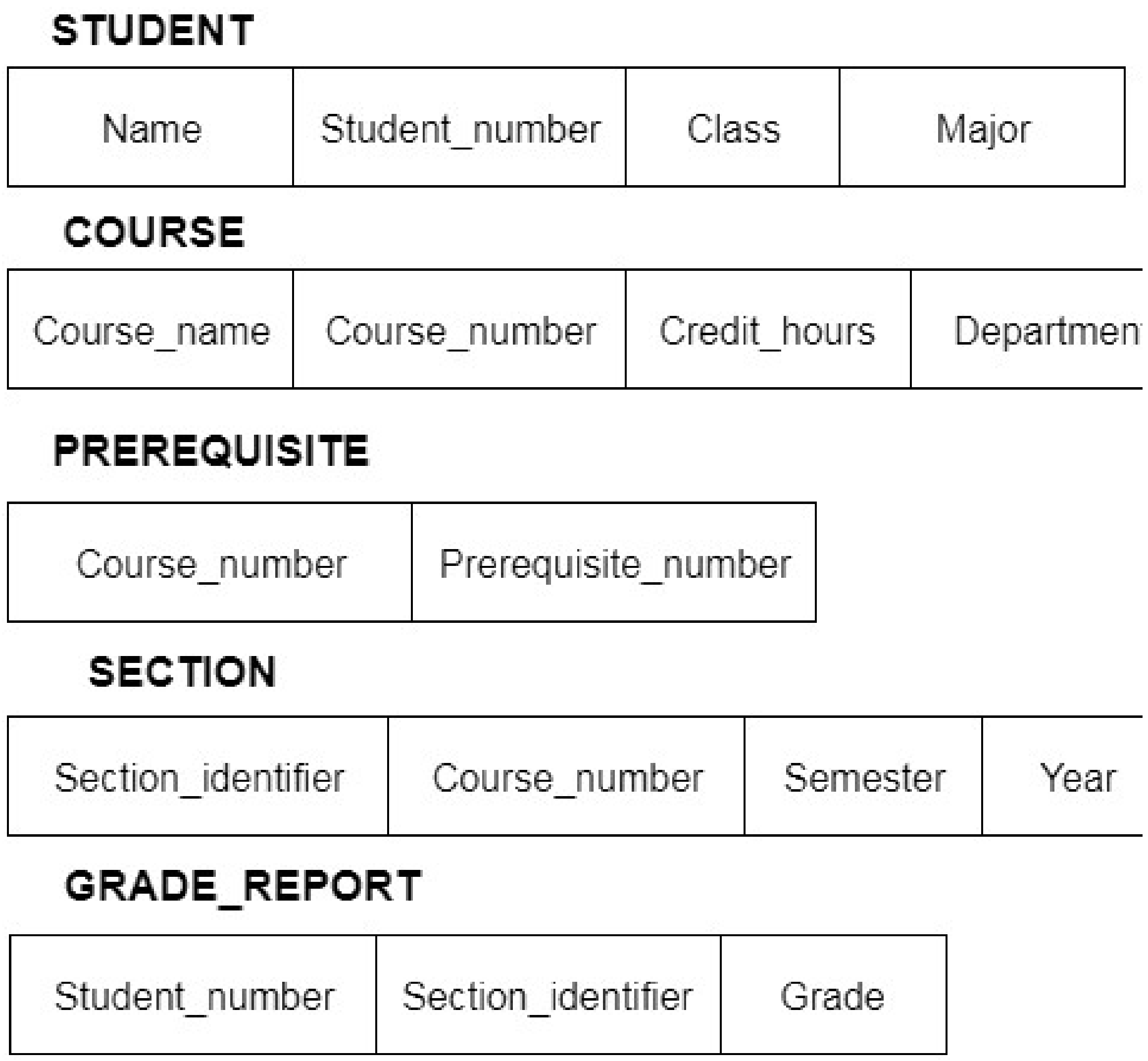
- The data which is stored in the database at a particular moment of time is called an instance of the database.
- The overall design of a database is called schema.
- A database schema is the skeleton structure of the database. It represents the logical view of the entire database.
- A schema contains schema objects like table, foreign key, primary key, views,

columns, data types, stored procedure, etc.

- A database schema can be represented by using the visual diagram. That diagram shows the database objects and relationship with each other.
- A database schema is designed by the database designers to help programmers whose software will interact with the database. The process of database creation is called data modeling.

A schema diagram can display only some aspects of a schema like the name of record type, data type, and constraints. Other aspects can't be specified through the schema diagram. For example, the given figure neither show the data type of each data item nor the relationship among various files.

In the database, actual data changes quite frequently. For example, in the given figure, the database changes whenever we add a new grade or add a student. The data at a particular moment of time is called the instance of the database.



STUDENT

Name	Student_number	Class	Major

COURSE

Course_name	Course_number	Credit_hours	Departmen

PREREQUISITE

Course_number	Prerequisite_number

SECTION

Section_identifier	Course_number	Semester	Year

GRADE_REPORT

Student_number	Section_identifier	Grade

Data Independence

- Data independence can be explained using the three-schema architecture.
- Data independence refers characteristic of being able to modify the schema at one level of the database system without altering the schema at the next higher level.

There are two types of data independence:

1. Logical Data Independence

- Logical data independence refers characteristic of being able to change the conceptual schema without having to change the external schema.
- Logical data independence is used to separate the external level from the conceptual view.
- If we do any changes in the conceptual view of the data, then the user view of the data would not be affected.
- Logical data independence occurs at the user interface level.

2. Physical Data Independence

- Physical data independence can be defined as the capacity to change the internal schema without having to change the conceptual schema.
- If we do any changes in the storage size of the database system server, then the Conceptual structure of the database will not be affected.
- Physical data independence is used to separate conceptual levels from the internal levels.
- Physical data independence occurs at the logical interface level.

Database Language

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

Types of Database Language

1. Data Definition Language

- **DDL** stands for **D**ata **D**efinition **L**anguage. It is used to define database structure or pattern.

- It is used to create schema, tables, indexes, constraints, etc. in the database.
- Using the DDL statements, you can create the skeleton of the database.
- Data definition language is used to store the information of metadata like the number of tables and schemas, their names, indexes, columns in each table, constraints, etc.

Here are some tasks that come under DDL:

- **Create:** It is used to create objects in the database.
- **Alter:** It is used to alter the structure of the database.
- **Drop:** It is used to delete objects from the database.
- **Truncate:** It is used to remove all records from a table.
- **Rename:** It is used to rename an object.
- **Comment:** It is used to comment on the data dictionary.

These commands are used to update the database schema that's why they come under Data definition language.

2. Data Manipulation Language

DML stands for **D**ata **M**anipulation **L**anguage. It is used for accessing and manipulating data in a database. It handles user requests.

- **Select:** It is used to retrieve data from a database.
- **Insert:** It is used to insert data into a table.
- **Update:** It is used to update existing data within a table.
- **Delete:** It is used to delete all records from a table.
- **Merge:** It performs UPSERT operation, i.e., insert or update operations.
- **Call:** It is used to call a structured query language or a Java subprogram.
- **Explain Plan:** It has the parameter of explaining data.

- **Lock Table:** It controls concurrency.

3. Data Control Language

- **DCL** stands for **D**ata **C**ontrol **L**anguage. It is used to retrieve the stored or saved data.
- The DCL execution is transactional. It also has rollback parameters.

  (But in Oracle database, the execution of data control language does not have the feature of rolling back.)

Here are some tasks that come under DCL:

- **Grant:** It is used to give user access privileges to a database.
- **Revoke:** It is used to take back permissions from the user.

There are the following operations which have the authorization of Revoke:

CONNECT, INSERT, USAGE, EXECUTE, DELETE, UPDATE and SELECT.

4. Transaction Control Language

TCL is used to run the changes made by the DML statement. TCL can be grouped into a logical transaction.

Here are some tasks that come under TCL:

- **Commit:** It is used to save the transaction on the database.
- **Rollback:** It is used to restore the database to original since the last Commit.

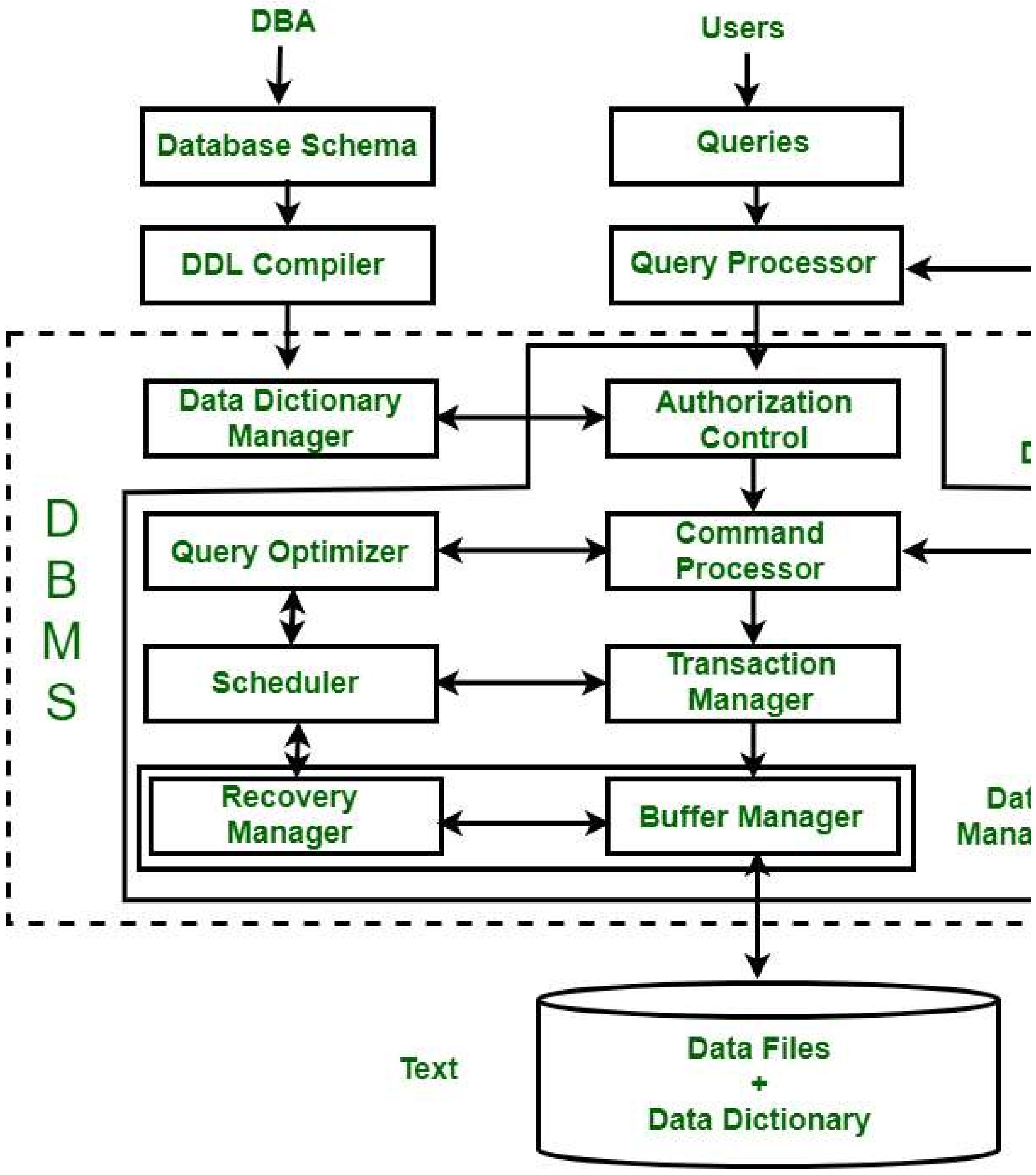
Structure of Database Management System

Database Management System (DBMS) is a software that allows access to data stored in a database and provides an easy and effective method of –

- Defining the information.
- Storing the information.
- Manipulating the information.
- Protecting the information from system crashes or data theft.

- Differentiating access permissions for different users.

Please be note that the Structure of Database Management System is also referred to as ***Overall System Structure*** *or* ***Database Architecture*** *but it is different from the* ***tier architecture*** *of Database.*
The database system is divided into three components: Query Processor, Storage Manager, and Disk Storage. These are explained as following below.



Architecture of DBMS

1. Query Processor :
It interprets the requests (queries) received from end user via an application program into instructions. It also executes the user request which is received from the DML compiler.
Query Processor contains the following components –

- **DML Compiler –**
  It processes the DML statements into low level instruction (machine language), so that they can be executed.

- **DDL Interpreter –**
  It processes the DDL statements into a set of table containing meta data (data about data).

- **Embedded DML Pre-compiler –**
  It processes DML statements embedded in an application program into procedural calls.

- **Query Optimizer –**
  It executes the instruction generated by DML Compiler.

2. Storage Manager :
Storage Manager is a program that provides an interface between the data stored in the database and the queries received. It is also known as Database Control System. It maintains the consistency and integrity of the database by applying the constraints and executes the DCL statements. It is responsible for updating, storing, deleting, and retrieving data in the database.
It contains the following components –

- **Authorization Manager –**
  It ensures role-based access control, i.e,. checks whether the particular person is privileged to perform the requested operation or not.

- **Integrity Manager –**
  It checks the integrity constraints when the database is modified.

- **Transaction Manager –**
  It controls concurrent access by performing the operations in a scheduled way that it receives the transaction. Thus, it ensures that the database remains in the consistent state before and after the execution of a transaction.

- **File Manager –**
  It manages the file space and the data structure used to represent information in the database.

- **Buffer Manager –**
  It is responsible for cache memory and the transfer of data between the secondary storage and main memory.

3. Disk Storage: It contains the following components –

- **Data Files –**
  It stores the data.

- **Data Dictionary –**
  It contains the information about the structure of any database object. It is the repository of information that governs the metadata.

- **Indices –**
  It provides faster retrieval of data item.