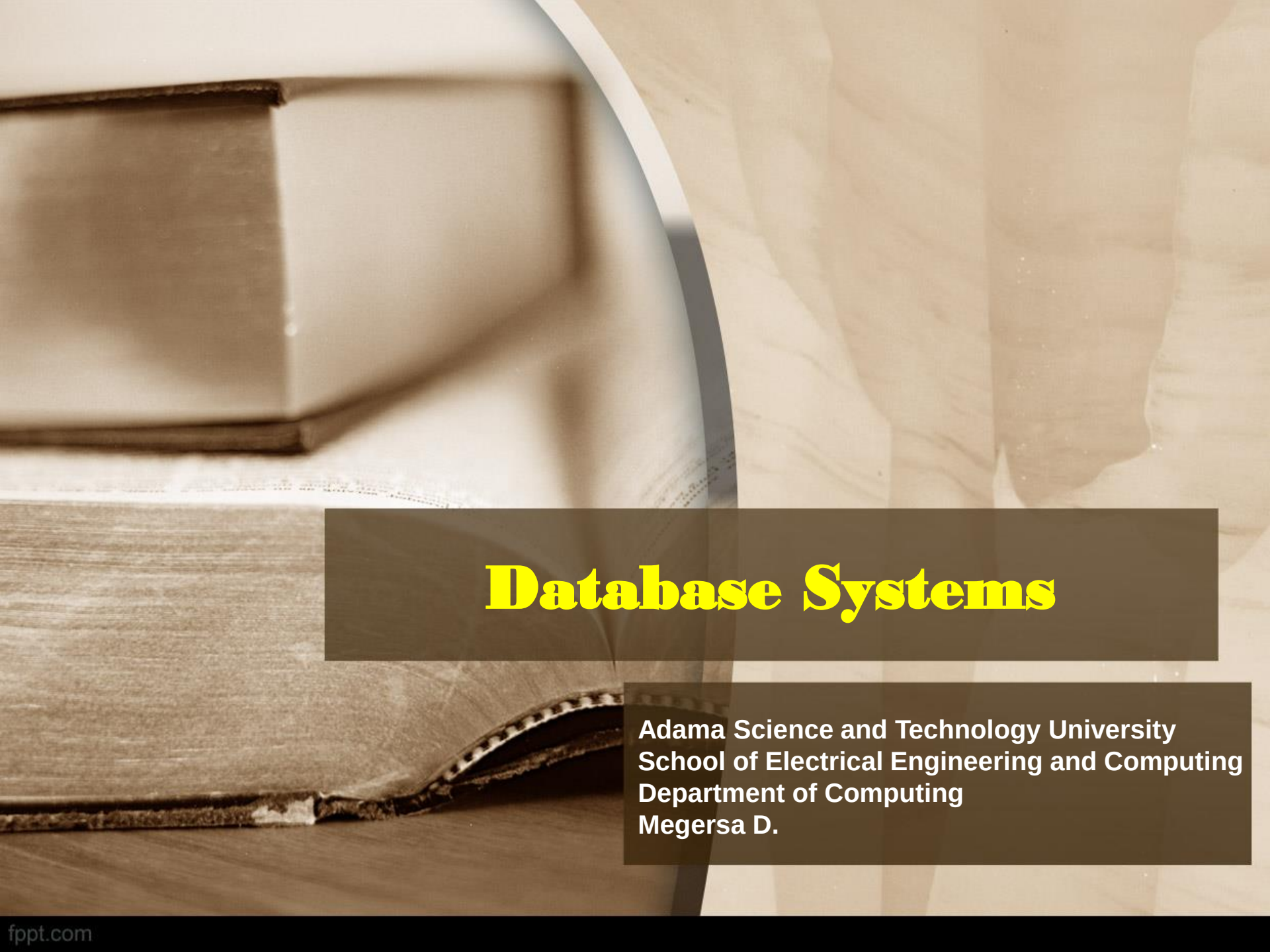

Database Systems

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Chapter One:

Introduction to Database System

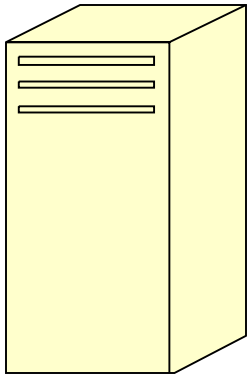
- ✓ *What is database*
- ✓ *Database management system and its components*
- ✓ *Database design life cycle*
- ✓ *Roles in Database Design and Use*
- ✓ *database Architecture*

1. What is Database

- A very large integrated Collection of data
- They are used to maintain internal records, to present data to customers and clients on the World-Wide-Web, and to support many other commercial processes.
- Model Real world enterprise. Example. Entities and relationship.
- Database management system(DBMS) – a powerful tool(software package) for creating and managing large amounts of data efficiently and allowing it to persist over long periods of time, safely.
- data management involves both **definition** and the **manipulation** of the data
  - ***So the term database refers to a collection of data that is managed by a DBMS.***
- **Thus the DB course is about:**
  - ✓ How to organize data ;Supporting multiple users; Efficient and effective data retrieval ;Secured and reliable storage of data; Maintaining consistent data

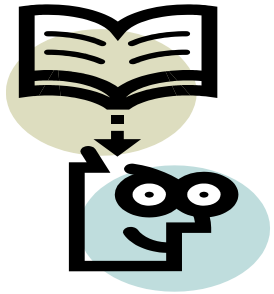
- *What is a Database?- It is a* collection of related facts

Filing Cabinet



Hard disk full of data

Diary



Library

DBMS + Database

=

Database System

- Data management passes through the different levels of development. The common are three

I. **Manual Approach**

- ✓ data storage and retrieval follows the primitive and traditional way of information handling where cards and paper are used for the purpose. example
  - ❖ Files for as many event and objects as the organization has are used to store information.
  - ❖ Each of the files containing various kinds of information is labelled (piece of papers) and stored in one ore more cabinets (shelves or displaying articles).
  - ❖ The cabinets could be kept in safe places for security purpose based on the sensitivity of the information contained in it.
  - ❖ Insertion and retrieval is done by searching first for the right cabinet then for the right the file then the

- **Limitations of the Manual approach**
  - ✓ Prone to error
  - ✓ Difficult to update, retrieve, integrate
  - ✓ You have the data but it is difficult to compile the information
  - ✓ Cross referencing is difficult

2. Traditional File Based Approach

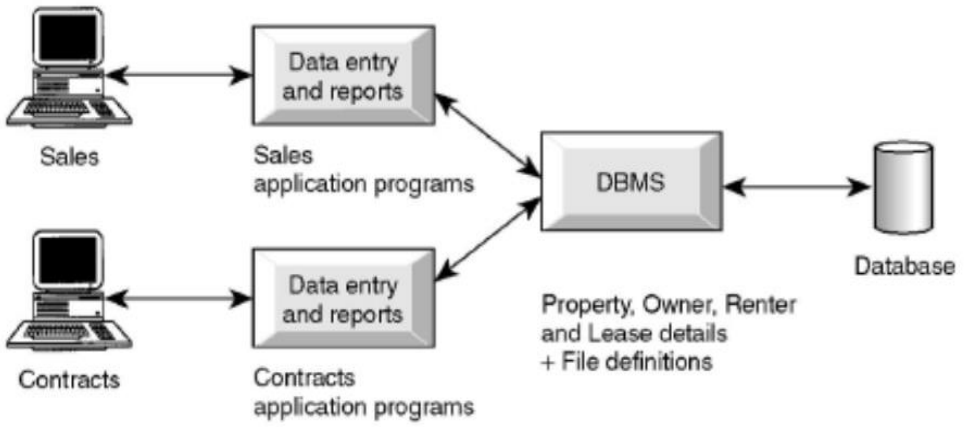
- uses computer for data processing to the business community, via the device for data storage and processing increase.
  - ✓ File based systems were an early attempt (make effort to achieve) to computerize the manual filing system.
  - ✓ This approach is the decentralized computerized data handling method.
  - ✓ Since every application defines and manages its own data, the system is subjected to serious data duplication problem.

Limitations of the Traditional File Based approach

- Limited data sharing- every application maintains its own data.
- Duplication or redundancy of data (*money and time cost* and *loss of data integrity*)
- The problem in **"update anomalies"**. three types of anomalies;
  - ✓ **Modification Anomalies**: a problem experienced when one ore more data value is modified on one application program but not on others containing the same data set.
  - ✓ **Deletion Anomalies**: a problem encountered where one record set is deleted from one application but remain untouched in other application programs.
  - ✓ **Insertion Anomalies**: a problem experienced when ever there is new data item to be recorded, and the recording is not made in all the applications.

3. Database Approach

- that database systems is presented for user with a view of data organized as tables called relations
- IT emphasizes (make more clear) the integration and sharing of data throughout the organization.
- Database is a collection of logically related data where these logically related data comprises entities, attributes, relationships, and business rules of an organization's information.
- Database is deigned once and used simultaneously by many users.



Benefits of the database approach

- *Data can be shared*: two or more users can access and use same data instead of storing data in redundant manner for each user.
- *Improved accessibility of data*: by using structured query languages, the users can easily access data without programming experience.
- *Quality data can be maintained*: the different integrity constraints in the database approach will maintain the quality leading to better decision making
- *Integrity can be maintained*: data at different applications will be integrated together with additional constraints to facilitate (make easier) *validity* and *consistency (done in the same way over time)* of shared data resource.
- *Security measures can be enforced*: the shared data can be secured by having different levels of clearance
- *Speed*: data storage and retrieval is fast
- *Centralized information control:* since relevant data in the organization will be stored at one repository, it can be controlled and managed at the central level.

Limitations and risk of Database Approach

- ✓ Complexity in designing and managing data
- ✓ The cost and risk during conversion from the old to the new system
- ✓ High cost to be incurred to develop and maintain the system
- ✓ Complex backup and recovery services from the users perspective
- ✓ Reduced performance due to centralization and data independency
- ✓ High impact on the system when failure occurs to the central system.

2. Database Management System (DBMS)

- a full scale DBMS should at least have the following services to provide to the user

i. Data ***storage***, ***retrieval*** and ***update*** in the database

ii. A user accessible ***catalogue***

iii. ***Transaction support service***: ALL or NONE transaction, which minimize data inconsistency.

iv. ***Concurrency Control Services***: access and update on the database by different users simultaneously should be implemented correctly.

v. ***Recovery Services***: a mechanism for recovering the database after a failure must be available.

vi. ***Authorization Services*** (Security): must support the implementation of access and authorization service to database administrator and users.

vii. ***Integrity Services***: rules about data and the change that took place on the data, correctness and consistency of stored data, and quality of data based on business constraints.

viii. Services to promote ***data independency*** between the data and the application

Database Languages

- DBMS should have facilities to define the database, manipulate the content of the database and control the database
- It provides the following facilities:
  - ✓ **Data Definition Language (DDL):**
    - ❖ Language used to define each data element required by the organization.
    - ❖ Commands for setting up schema or database
    - ❖ These commands are used to setup a database, create, delete and alter table with the facility of handling constraints
  - ✓ **Data Manipulation Language (DML):**
    - ❖ Is a core command used by end-users and programmers to store, retrieve, and access the data in the database e.g. SQL
    - ❖ Since the required data or Query by the user will be extracted using this type of language, it is also called "Query Language"

- Taking a DBMS as a system, To design and use a database, there will be the interaction or integration of Hardware, Software, Data, Procedure and People.

  i. **Hardware**: These components are comprised of various types of personal computers, mainframe or any server computers to be used in multi-user system, network infrastructure, and other peripherals required in the system.

  ii. **Software**: are collection of commands and programs used to manipulate the hardware to perform a function. Like the DBMS software, application programs, operating systems, network software, language software and other relevant software.

  iii. **Procedure**: this is the rules and regulations on *how to design and use* a database. It includes procedures like how to log on to the DBMS, how to use facilities, how to start and stop transaction, how to make backup, how to treat hardware and software failure…

iv. **Data**:

- ✓ Data is the most important component to the user of the database. There are two categories of data in any database system: that is *Operational* and *Metadata*.
  - ❖ Operational data is the data actually stored in the system to be used by the user.
  - ❖ Metadata is the data that is used to store information about the database itself.
- ✓ The structure of the data in the database is called the ***schema***, which is composed of the *Entities*, *Properties of entities*, and *relationship between entities and business constraints*.

v. **People**: this component is composed of the people in the organization that are responsible or play a role in designing, implementing, managing, administering and using the resources in the database. This component includes group of people who are experts or user of DB

3. Database Development Life Cycle (DDLC)

- major steps in database design are:

i. **Planning**: that is identifying information gap in an organization and propose a database solution to solve the problem.

ii. **Analysis**: that concentrates more on fact finding about the problem or the opportunity. Feasibility analysis, requirement determination and structuring, and selection of best design method are also performed at this phase.

iii. **Design: The** phase is further divided into three sub-phases.

- a. **Conceptual Design**: concise description of the data, data type, relationship between data and constraints on the data.
  - There is no implementation or physical detail consideration.
  - Used to elicit and structure all information requirements

- ❖b. **Logical Design**: a higher level conceptual abstraction with selected *specific data model* to implement the data structure.
  - It is particular DBMS **independent** and with no other physical considerations.
- ❖c. **Physical Design**: physical implementation of the logical design of the database with respect to internal storage and file structure of the database for the selected DBMS.
  - To develop all technology and organizational specification.

iv. **Implementation**: the testing and deployment of the designed database for use.

v. **Operation and Support**: administering and maintaining the operation of the database system and providing support to users.

5. Roles in Database Design and Use

- There are group of roles played by different stakeholders of the designing and operation of a database system. These are:

1. **Database Administrator (DBA)**
   - ✓ Responsible to oversee, control and manage the database resources
   - ✓ Authorizing access to the database
   - ✓ Coordinating and monitoring the use of the database
   - ✓ Responsible for determining and acquiring hardware and software resources
   - ✓ Accountable for problems like poor security, poor performance of the system
   - ✓ Involves in all steps of database development
2. **Database Designer (DBD)**
   - ✓ Identifies the data to be stored and choose the appropriate structures to represent and store the data.
   - ✓ Should understand the user requirement and should choose how the user views the database.
   - ✓ Involve on the design phase before the implementation of the database system.

3. **Application Programmer and Systems Analyst**

- ✓ System analyst determines the user requirement and how the user wants to view the database.
- ✓ The application programmer implements these specifications as programs; code, test, debug, document and maintain the application program.
- ✓ The application programmer determines the interface on how to retrieve, insert, update and delete data in the database.
- ✓ The application could use any high level programming language according to the availability, the facility and the required service.

4. End Users

- ✓ Workers, whose job requires accessing the database frequently for various purposes, there are different group of users in this category. Like Naïve Users and Sophisticated Users

Example of a Database

Part of a UNIVERSITY environment. Information concerning students, courses, and grades in a university environment

- **Some mini-world *entities*:**
  - ✓ STUDENTs
  - ✓ COURSEs
  - ✓ SECTIONs (of COURSEs)
  - ✓ DEPARTMENTs
  - ✓ INSTRUCTORs
- **Some mini-world *relationships*:**
  - SECTIONs *are of* specific COURSEs
  - STUDENTs *take* SECTIONs
  - COURSEs *have* prerequisite COURSEs
  - INSTRUCTORs *teach* SECTIONs
  - COURSEs *are offered by* DEPARTMENTs
  - STUDENTs *major in* DEPARTMENTs

STUDENT	Name	StudentNumber	Class	Major
	Smith	17	1	CS
	Brown	8	2	CS

COURSE	CourseName	CourseNumber	CreditHours	Department
	Intro to Computer Science	CS1310	4	CS
	Data Structures	CS3320	4	CS
	Discrete Mathematics	MATH2410	3	MATH
	Database	CS3380	3	CS

SECTION	SectionIdentifier	CourseNumber	Semester	Year	Instructor
	85	MATH2410	Fall	98	King
	92	CS1310	Fall	98	Anderson
	102	CS3320	Spring	99	Knuth
	112	MATH2410	Fall	99	Chang
	119	CS1310	Fall	99	Anderson
	135	CS3380	Fall	99	Stone

GRADE_REPORT	StudentNumber	SectionIdentifier	Grade
	17	112	B
	17	119	C
	8	85	A
	8	92	A
	8	102	B
	8	135	A

PREREQUISITE	CourseNumber	PrerequisiteNumber
	CS3380	CS3320
	CS3380	MATH2410
	CS3320	CS1310

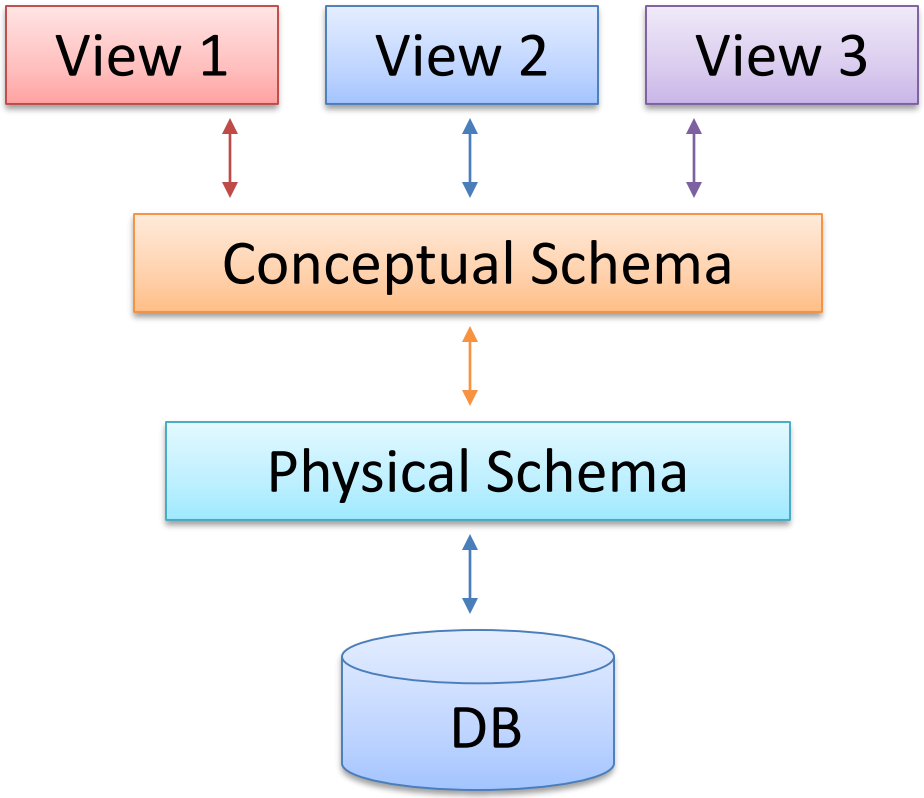
An Example (cont'd.)

- Construct UNIVERSITY database
  - ✓ Store data to represent each student, course, section, grade report, and prerequisite as a record in appropriate file
- Relationships among the records
- Manipulation involves querying and updating
- Examples of queries:
  - Retrieve the transcript
  - List the names of students who took the section of the 'Database' course offered in fall 2013 and their grades in that section
  - List the prerequisites of the '**Fundaments of Database**' course
- Examples of updates:
  - Change the class of 'Lemma' to sophomore
  - Create a new section for the 'Database' course for this semester
  - Enter a grade of 'A' for 'Lemma' in the 'Database' section of last semester

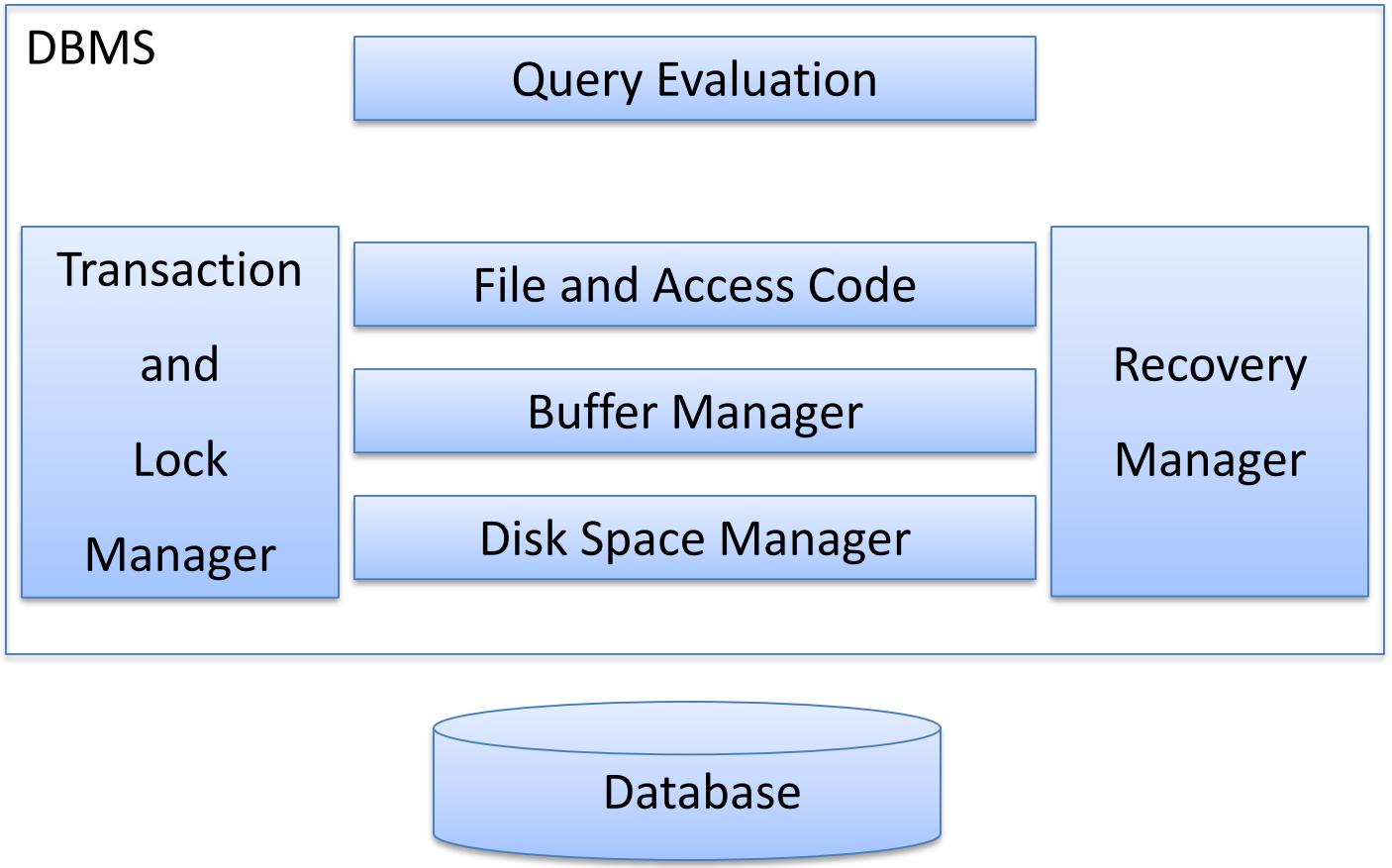
Data Abstraction(Categories of data models)

- Data can be described at three levels of abstraction
- Physical schema
  - ✓ The lowest level schema
  - ✓ Describes how data are stored and indexed
- Conceptual (or logical) schema
  - ✓ What (not how) data are stored
  - ✓ Describes data in terms of the data model
- External (or view) schema
  - ✓ The highest level schema
  - ✓ Describes how some users access the data
  - ✓ There can be many different views

Levels of Abstraction



Typical DBMS Structure/*Database System*



Database Components(Structure)

- **Disk space (storage) manager** – responsible for interaction with the OS file system
  - ✓ Allows other levels of the DBMS to consider the data as a collection of pages
- **Buffer manager** – responsible for bringing pages into main memory from disk
  - ✓ Including the management of a replacement policy when main memory is full
- **File and access code-** allows the query evaluation system to request data from lower levels

Database Components

- **Query evaluation** – most modern DBMSs will optimize queries
  - ✓ There are often multiple equivalent queries
  - ✓ The query optimizer determines an efficient execution plan for a query
- **Transaction lock manager** – responsible for allowing concurrent access
  - ✓ While maintaining data integrity
- **Recovery manager** – responsible for maintaining a log and restoring the system after a crash

Database System Architecture

A DBMS architecture is depending on its design and can be of the following types:

i. Centralized or 1-tier Architecture

- **Centralized DBMS:** combines everything into single system including- DBMS software, hardware, application programs and user interface processing software.
- it includes the following three things:

a. Specialized Servers with Specialized functions:

- File Servers
- Printer Servers
- Web Servers
- E-mail Servers

b. Clients:

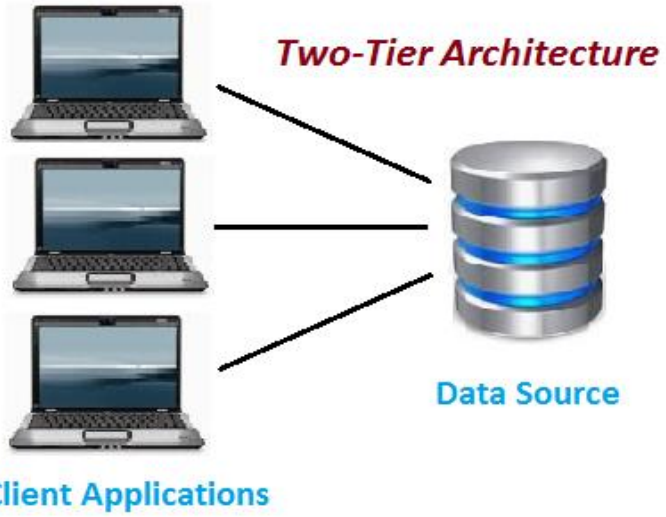
- Provide appropriate interfaces and a client-version of the system to access and utilize the server resources.
- Clients maybe diskless machines or PCs or Workstations with disks with only the client software installed.

c. DBMS Server

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

ii. Two Tier Client-Server Architecture

- **User Interface Programs and Application Programs** run on the client side
- Data is stored in a server.
- Interface called **ODBC (Open Database Connectivity)** provides an Application program interface (API) allow client side programs to call the DBMS.
- A client program may connect to several DBMSs.
- **Example** of Two-tier Architecture is a Contact Management System created Using MS- Access.



Physical two-tier client-server architecture

iii. Three Tier Client-Server Architecture

- Common for **Web applications**
- **Three-tier architecture** typically comprise a presentation tier, a business or data access tier, and a data tier. Three layers in the three tier architecture are as follows:

1)Client layer
2)Business layer
3) Data layer

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