DATABASE MANAGEMENT SYSTEM

Unit - 1

Database system architecture

Prepared By
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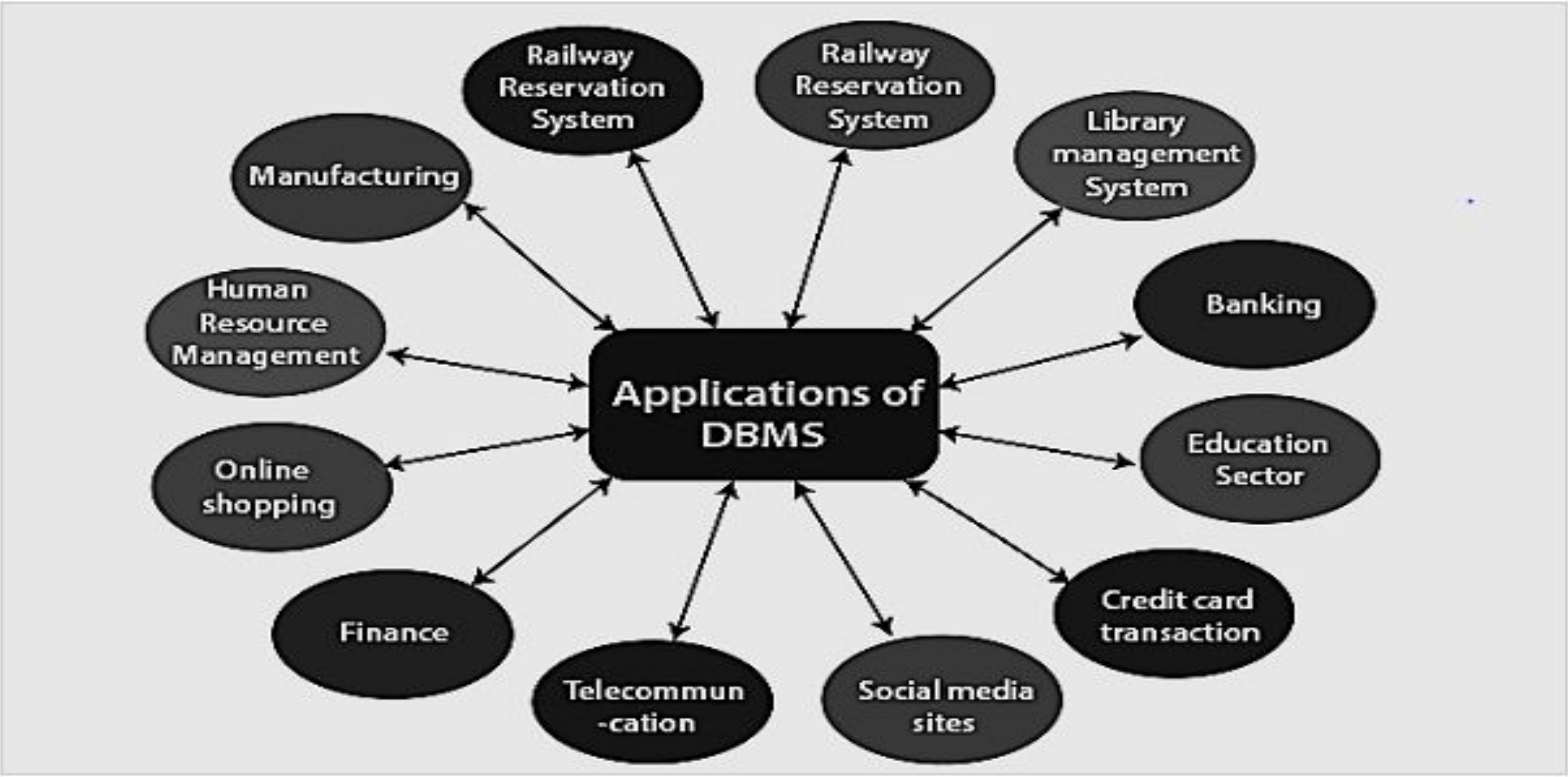
What is Database Management System?

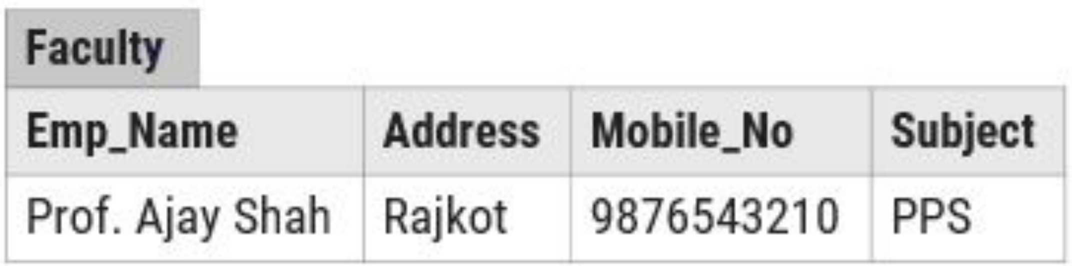
- **Data**
  - ❑ Fact that can be recorded or stored.
  - ❑ E.g. Person Name, Age, Gender and Weight etc.
- **Information**
  - ❑ When data is processed, organized, structured or presented in a given context so as to make it useful, it is called information.
- **Database**
  - ❑ A Database is a collection of inter-related (logically-related) data.
  - ❑ E.g. Books Database in Library, Student Database in University etc.
- **Management**
  - ❑ Manipulation, Searching and Security of data
  - ❑ E.g. Viewing Result in GTU website, Searching exam papers in GTU website, etc.
- **System**
  - ❑ Programs or tools used to manage database
  - ❑ E.g. SQL Server studio Express, Oracle, etc.
- **Database management system**
  - ❑ A database management system is a collection of inter-related data and set of programs to manipulate those data.
  - ❑ DBMS = Database + Set of programs
  - ❑ E.g. MS SQL Server, Oracle, My SQL, SQLite, MongoDB etc.

Applications of DBMS



Basic Terms

- **Metadata**
  - Metadata is **data about data**.
  - Data such as table name, column name, data type, authorized user and user access privileges for any table is called metadata for that table.



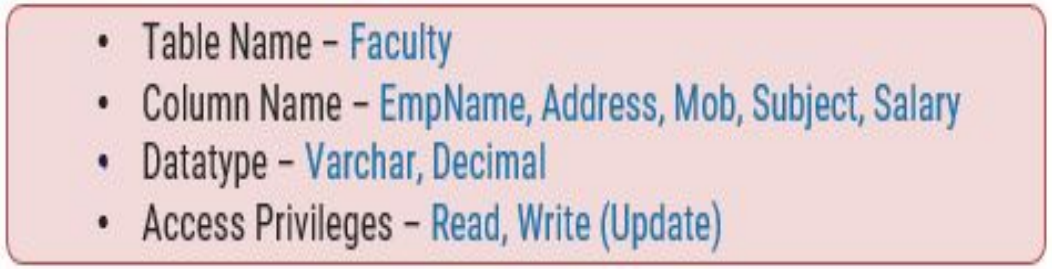
Faculty

Emp_Name	Address	Mobile_No	Subject
Prof. Ajay Shah	Rajkot	9876543210	PPS

  - Metadata of above table is:
    - Table name such as Faculty
    - Column name such as Emp_Name, Address, Mobile_No, Subject
    - Datatype such as Varchar, Decimal
    - Access privileges such as Read, Write (Update)

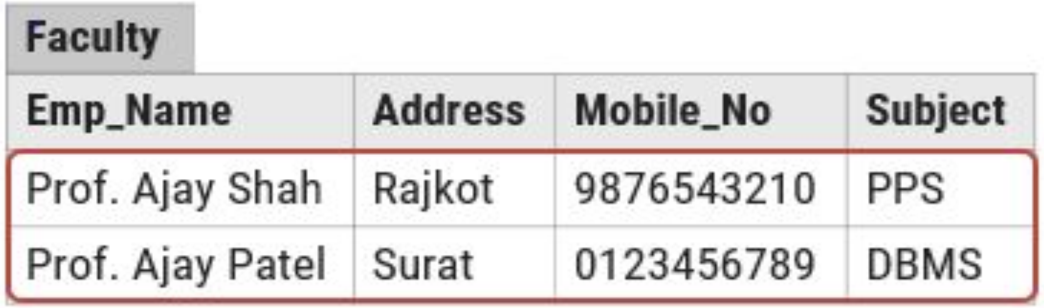
Basic Terms(Cont…)

- **Data dictionary**
  - A data dictionary is an information repository which **contains metadata**.



- Table Name – Faculty
- Column Name – EmpName, Address, Mob, Subject, Salary
- Datatype – Varchar, Decimal
- Access Privileges – Read, Write (Update)

- **Data warehouse**
  - A data warehouse is an information repository which **stores data**.

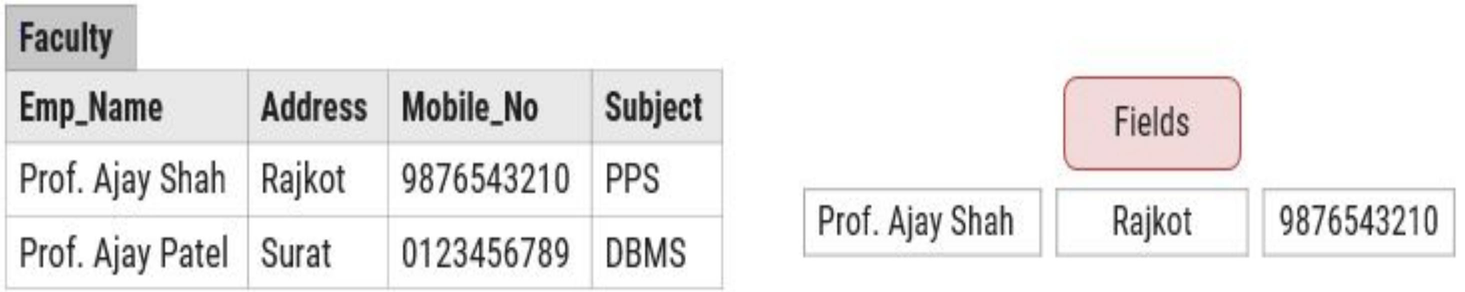


Faculty

Emp_Name	Address	Mobile_No	Subject
Prof. Ajay Shah	Rajkot	9876543210	PPS
Prof. Ajay Patel	Surat	0123456789	DBMS

Basic Terms(Cont…)

- **Field**
  - A field is a **character or group of characters** that have a specific meaning.
  - E.g, the value of Emp_Name, Address, Mobile_No etc are all fields of Faculty table.



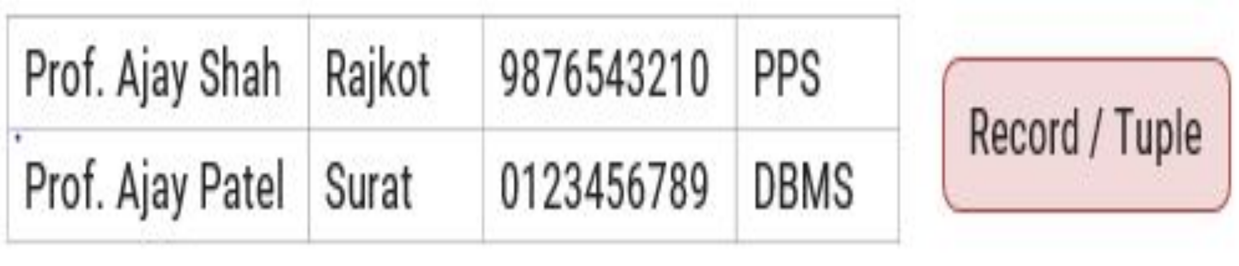
Faculty

Emp_Name	Address	Mobile_No	Subject
Prof. Ajay Shah	Rajkot	9876543210	PPS
Prof. Ajay Patel	Surat	0123456789	DBMS

Fields

Prof. Ajay Shah	Rajkot	9876543210

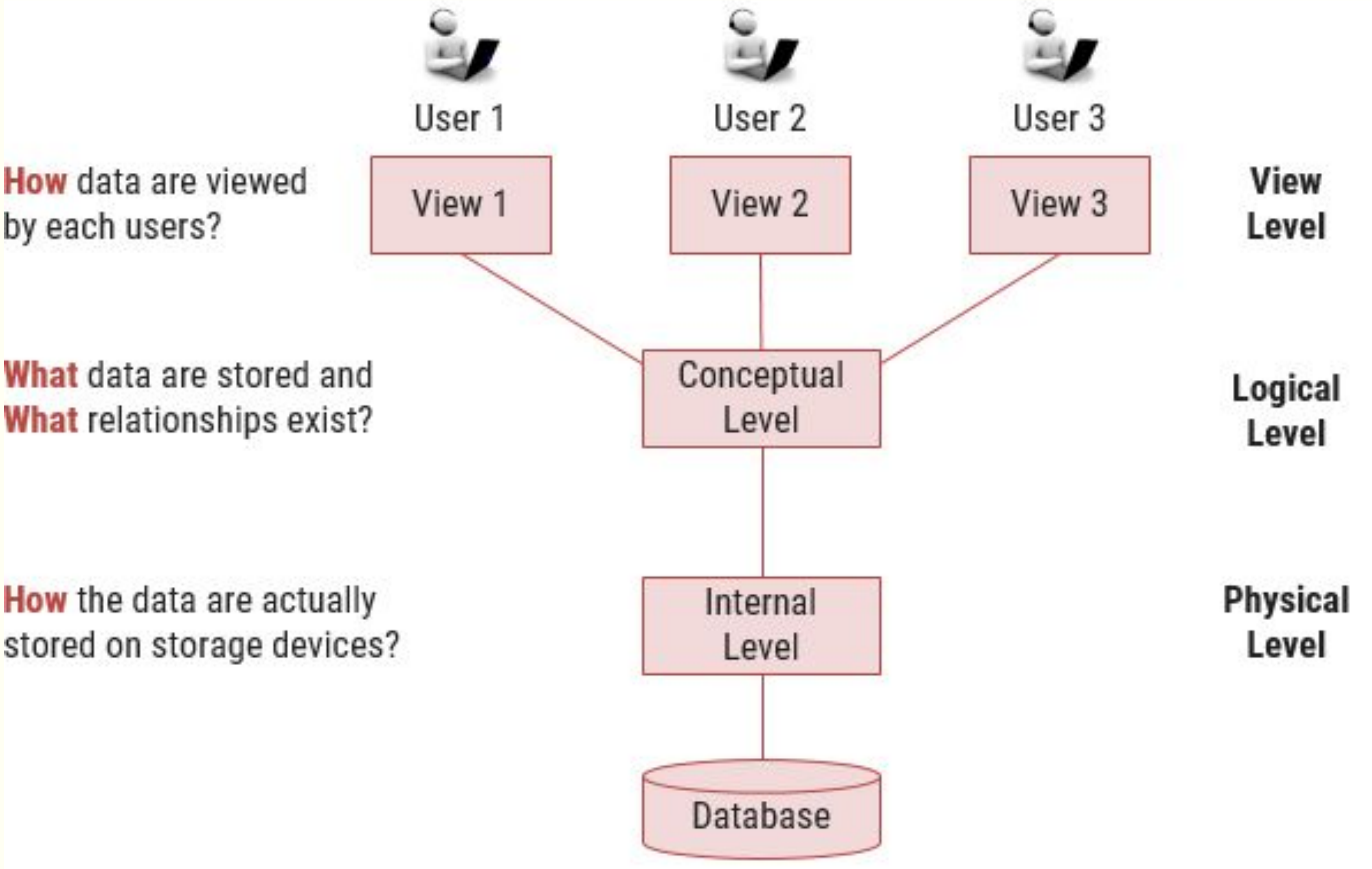
- **Record / Tuple**
  - A record is a **collection of logically related fields**.
  - E.g, the collection of fields (Emp_Name, Address, Mobile_No, Subject) forms a record for the Faculty.



Prof. Ajay Shah	Rajkot	9876543210	PPS
Prof. Ajay Patel	Surat	0123456789	DBMS

Record / Tuple

3 Levels ANSI SPARC Database System


User 1
User 2
User 3
How data are viewed by each users?
View 1
View 2
View 3
View Level
What data are stored and What relationships exist?
Conceptual Level
Logical Level
How the data are actually stored on storage devices?
Internal Level
Physical Level
Database

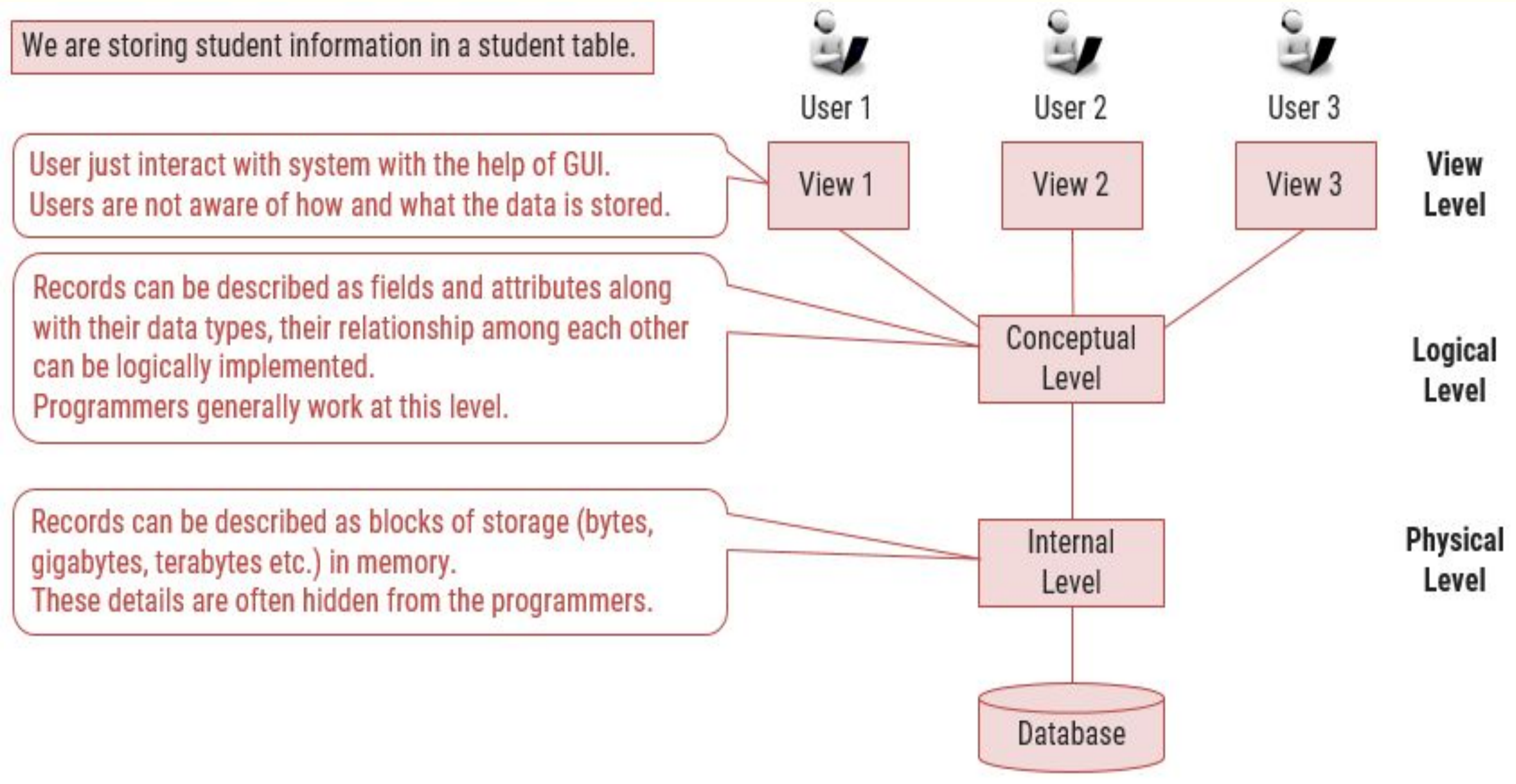
3 Levels ANSI SPARC Database System

- **Internal level (Physical level)**
  - It describes **how a data is stored** on the storage device.
  - Deals with physical storage of data.
    - Structure of records on disk - files, pages, blocks and indexes and ordering of records
  - Internal view is described by the internal schema.

- **Conceptual level (Logical level)**
  - **What data are stored and what relationships exist** among those data?
  - It hides low level complexities of physical storage.
  - For Example, STUDENT database may contain STUDENT and COURSE tables which will be visible to users but users are unaware about their storage.
  - Database administrator works at this level to determine what data to keep in the database.

- **External level (View level)**
  - It describes only part of the entire database that an end user concern or **how data are viewed** by each user.
  - Different user needs different views of the database, so there can be many views in a view level abstraction of the database. Used by end users and application programmers.
  - End users need to access only part of the database rather than the entire database.

3 Levels ANSI SPARC Database System



We are storing student information in a student table.

User just interact with system with the help of GUI.
Users are not aware of how and what the data is stored.

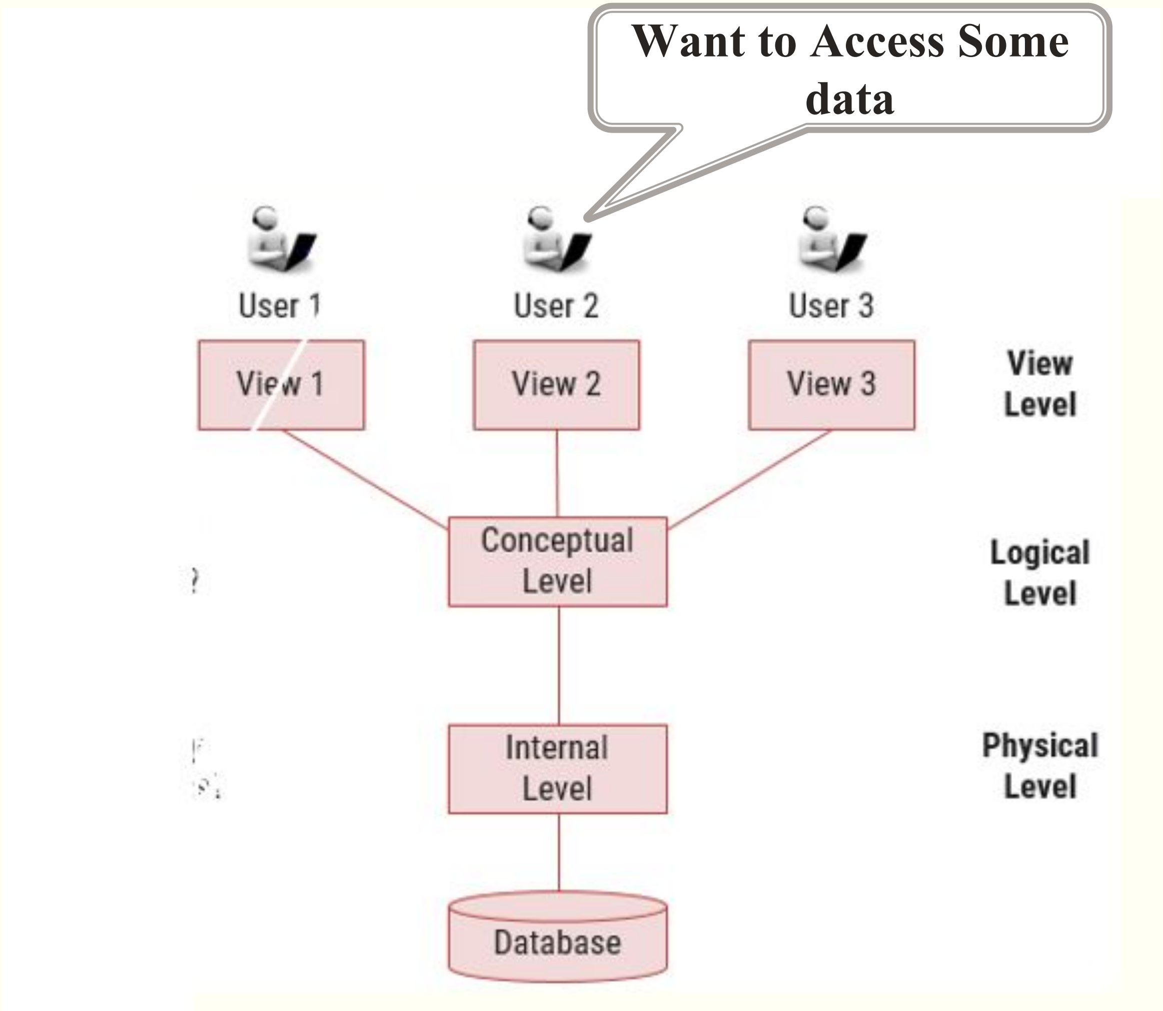
Records can be described as fields and attributes along with their data types, their relationship among each other can be logically implemented.
Programmers generally work at this level.

Records can be described as blocks of storage (bytes, gigabytes, terabytes etc.) in memory.
These details are often hidden from the programmers.

Data Abstraction in DBMS

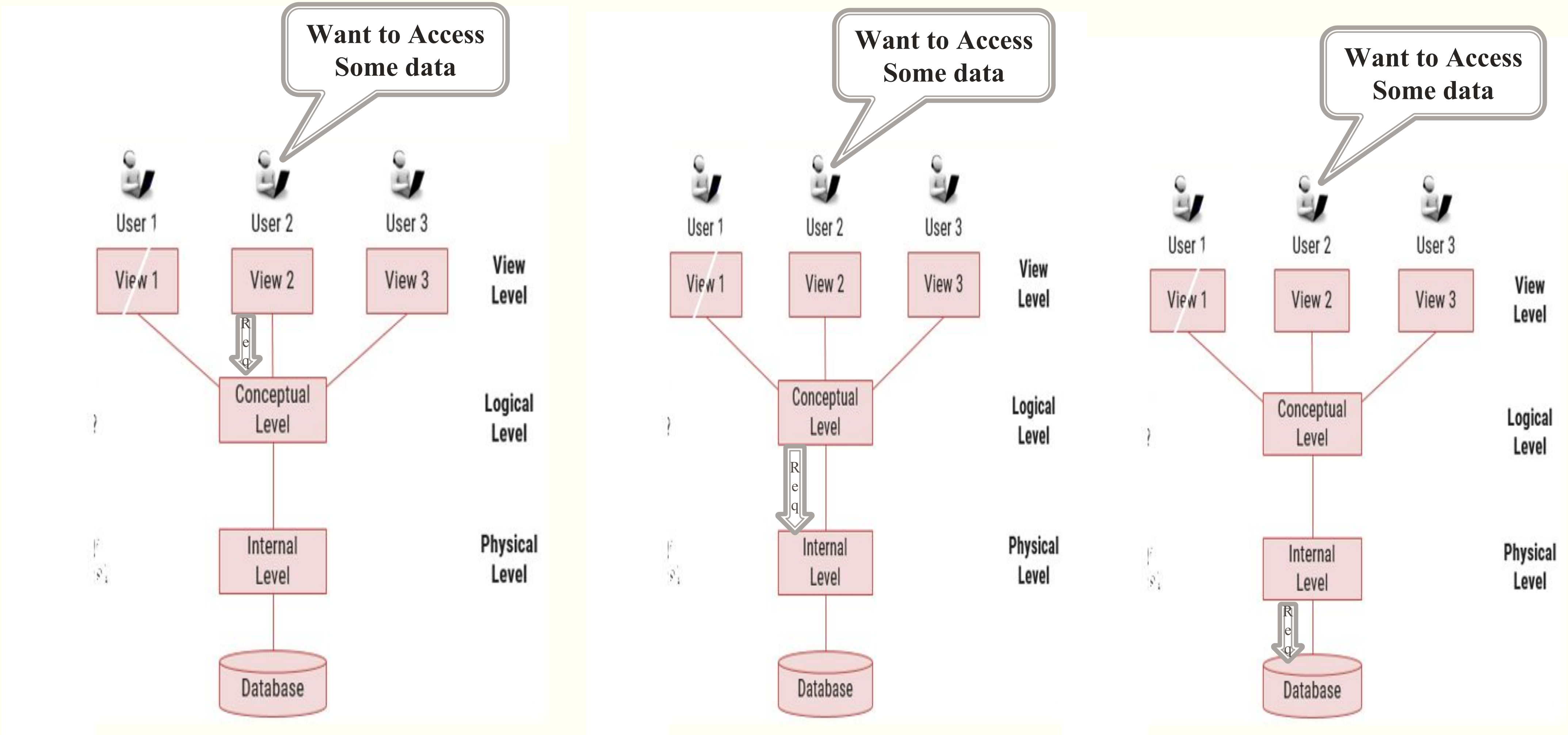
- Database systems are made-up of complex data structures.
- To ease the user interaction with database, the developers hide internal irrelevant details from users.
- This **process of hiding irrelevant details** from user is called data abstraction.

Mapping and Data Independence

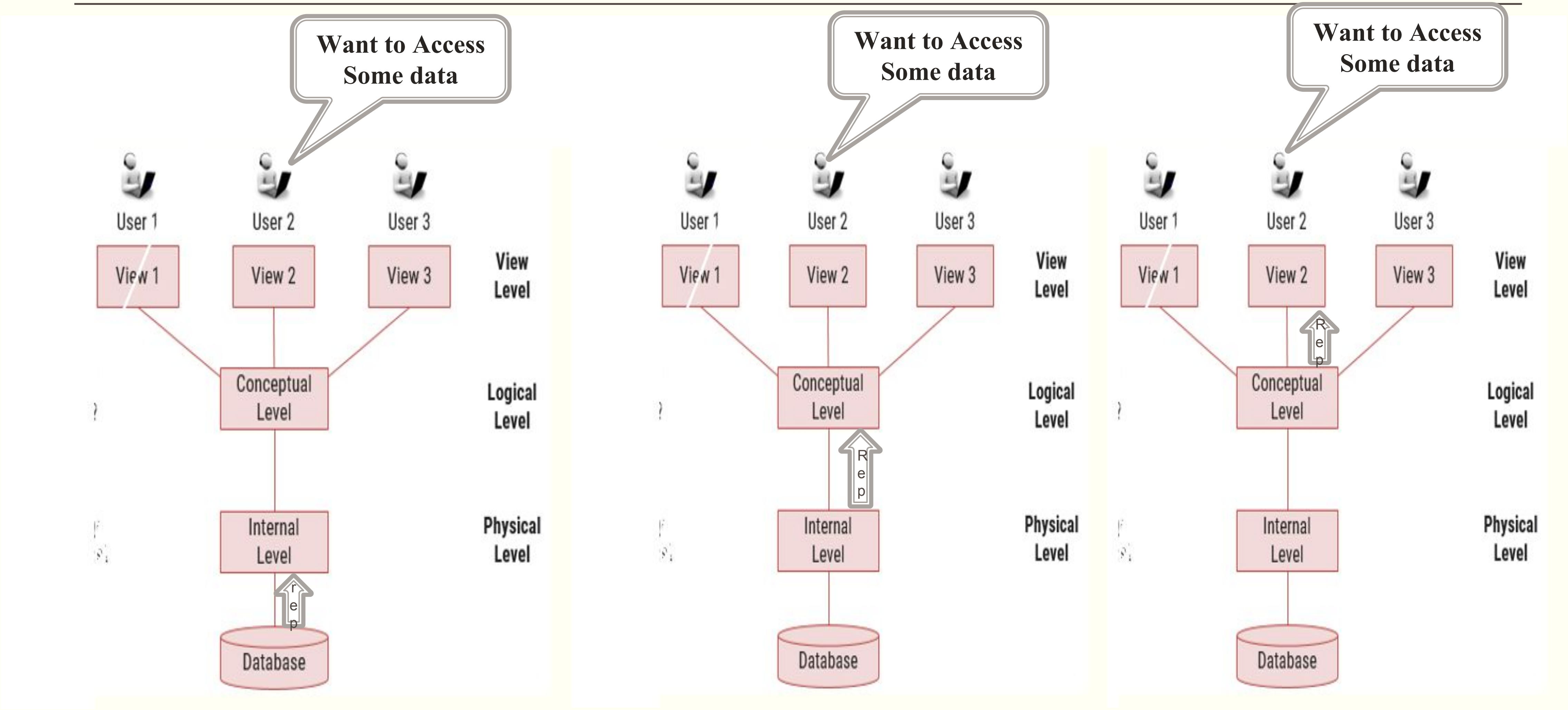


Want to Access Some data

Cont..


Want to Access Some data
User 1
User 2
User 3
View 1
View 2
View 3
View Level
Req
Conceptual Level
Logical Level
Internal Level
Physical Level
Database
Want to Access Some data
User 1
User 2
User 3
View 1
View 2
View 3
View Level
Conceptual Level
Logical Level
Req
Internal Level
Physical Level
Database
Want to Access Some data
User 1
User 2
User 3
View 1
View 2
View 3
View Level
Conceptual Level
Logical Level
Internal Level
Physical Level
Req
Database

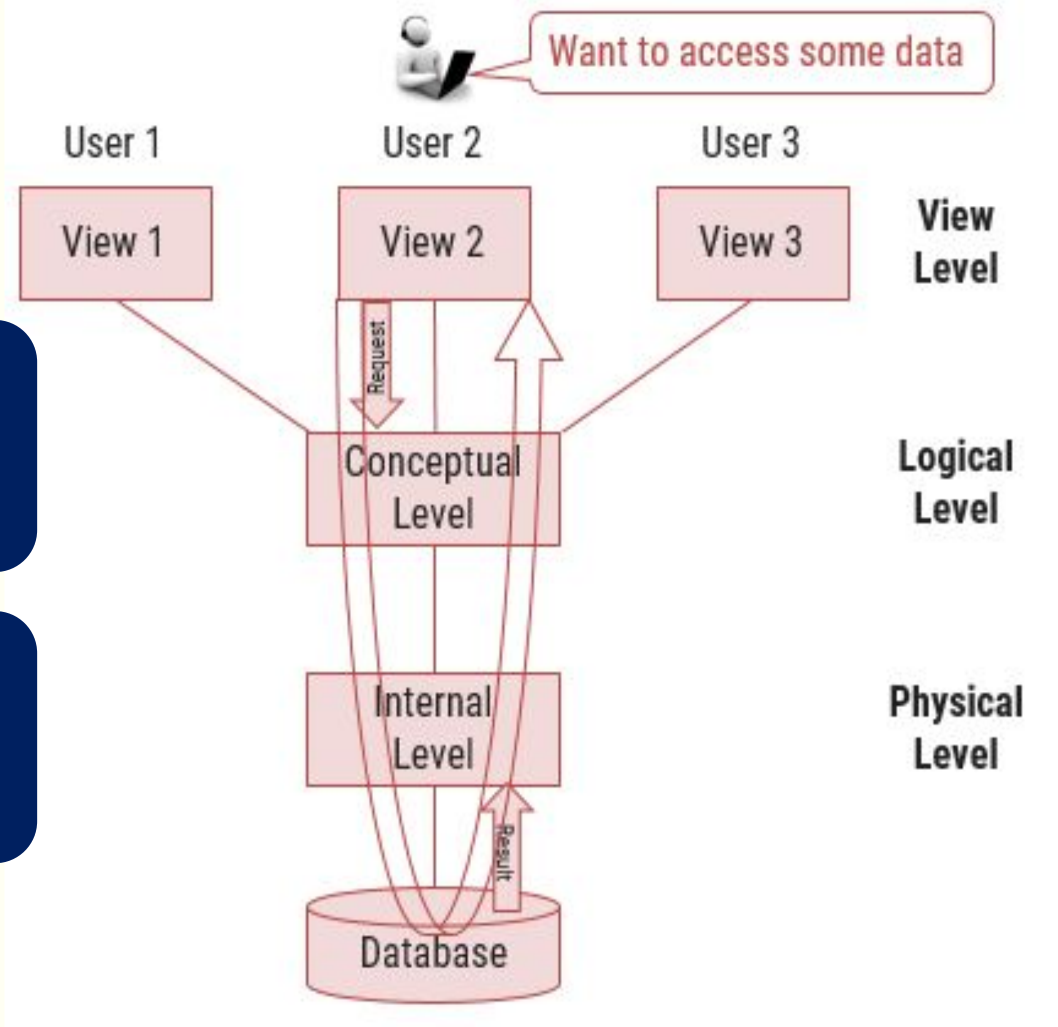
Cont..


Want to Access Some data
User 1
User 2
User 3
View 1
View 2
View 3
View Level
Conceptual Level
Logical Level
Internal Level
Physical Level
Database
rep
Want to Access Some data
User 1
User 2
User 3
View 1
View 2
View 3
View Level
Conceptual Level
Logical Level
Rep
Internal Level
Physical Level
Database
Want to Access Some data
User 1
User 2
User 3
View 1
View 2
View 3
View Level
Rep
Conceptual Level
Logical Level
Internal Level
Physical Level
Database

Cont..

Process of transforming requests and results between the three levels is called mapping.

Ability to modify a schema definition in one level without affecting a schema definition in the next higher level.



Types of Data Independence

- **Physical Data Independence**
  - Physical Data Independence is the ability to modify the physical schema without requiring any change in logical (conceptual) schema and application programs.
  - Modifications at the internal levels are occasionally necessary to improve performance.
  - Possible modifications at internal levels are changes in file structures, compression techniques, hashing algorithms, storage devices, etc.
- **Logical Data Independence**
  - Logical data independence is the ability to modify the conceptual schema without requiring any change in application programs.
  - Modification at the logical levels is necessary whenever the logical structure of the database is changed.
  - Application programs are heavily dependent on logical structures of the data they access. So any change in logical structure also requires programs to change.

Types of Database Users

- **Naive Users (End Users)**
  - **Unsophisticated users** who have zero knowledge of database system
  - End user interacts to database via sophisticated software or tools
  - e.g. Clerk in bank

- **Application Programmers**
  - **Programmers** who write software using tools such as Java, .Net, PHP etc…
  - e.g. Software developers

- **Sophisticated Users**
  - **Interact with database system** without using an application program
  - Use query tools like SQL
  - e.g. Analyst

- **Specialized Users (DBA)**
  - User **write specialized** database applications program
  - Use administration tools
  - e.g. Database Administrator

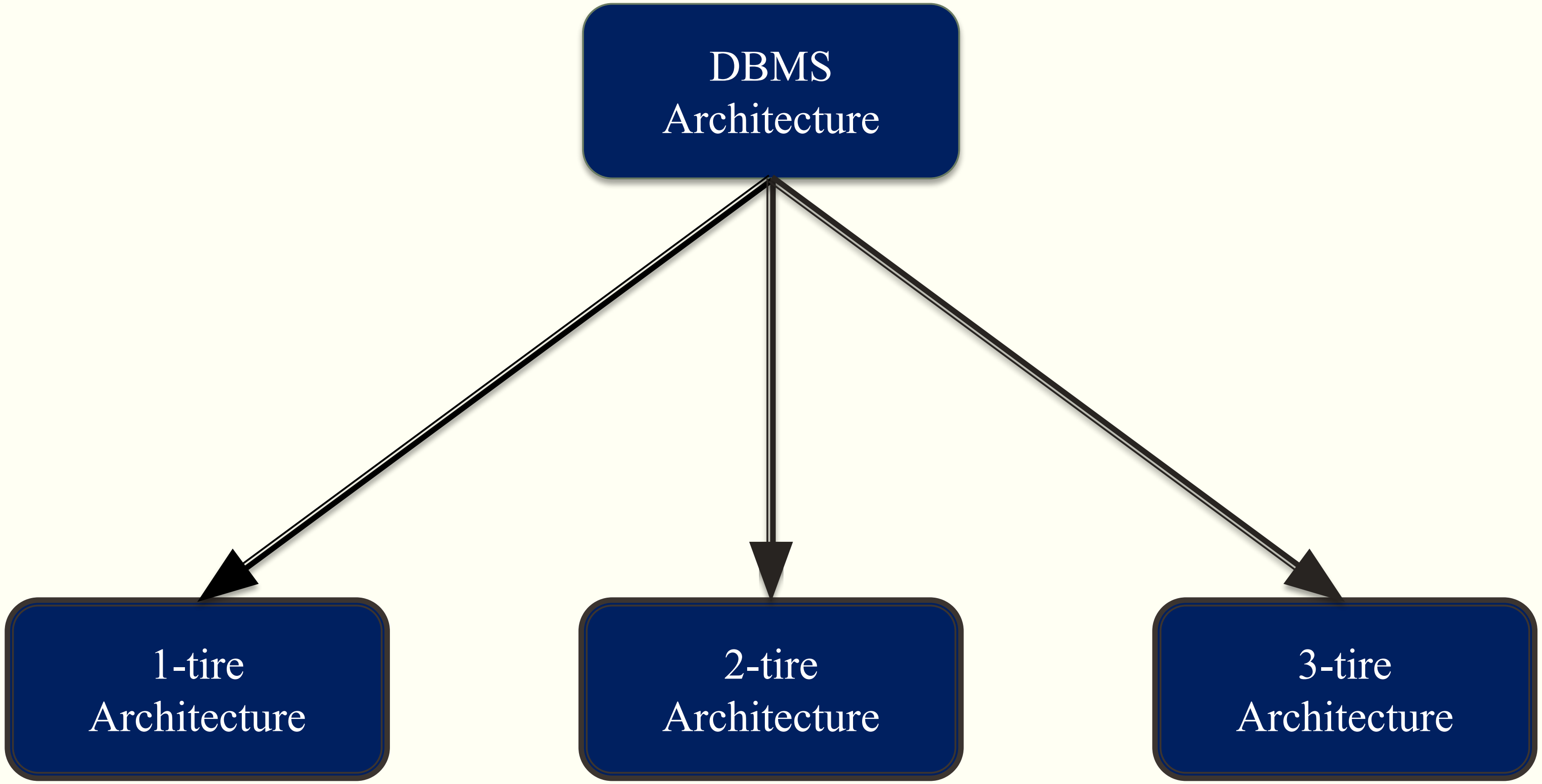
Role of DBA

- **Schema Definition**
  - DBA **defines the logical schema** of the database.
- **Storage Structure and Access Method Definition**
  - DBA **decides how the data is to be represented** in the database & how to access it.
- **Defining Security and Integrity Constraints**
  - DBA **decides on various security and integrity constraints**.
- **Granting of Authorization for Data Access**
  - DBA **determines which user needs access to which part** of the database.
- **Liaison with Users**
  - DBA **provide necessary data** to the user.

Cont..

- **Assisting Application Programmer**
  - DBA **provides assistance to application programmers** to develop application programs.
- **Monitoring Performance**
  - DBA **ensures that better performance is maintained** by making a change in the physical or logical schema if required.
- **Backup and Recovery**
  - DBA **backing up the database** on some storage devices such as DVD, CD or magnetic tape or remote servers and **recover the system in case of failures**, such as flood or virus attack from this backup.

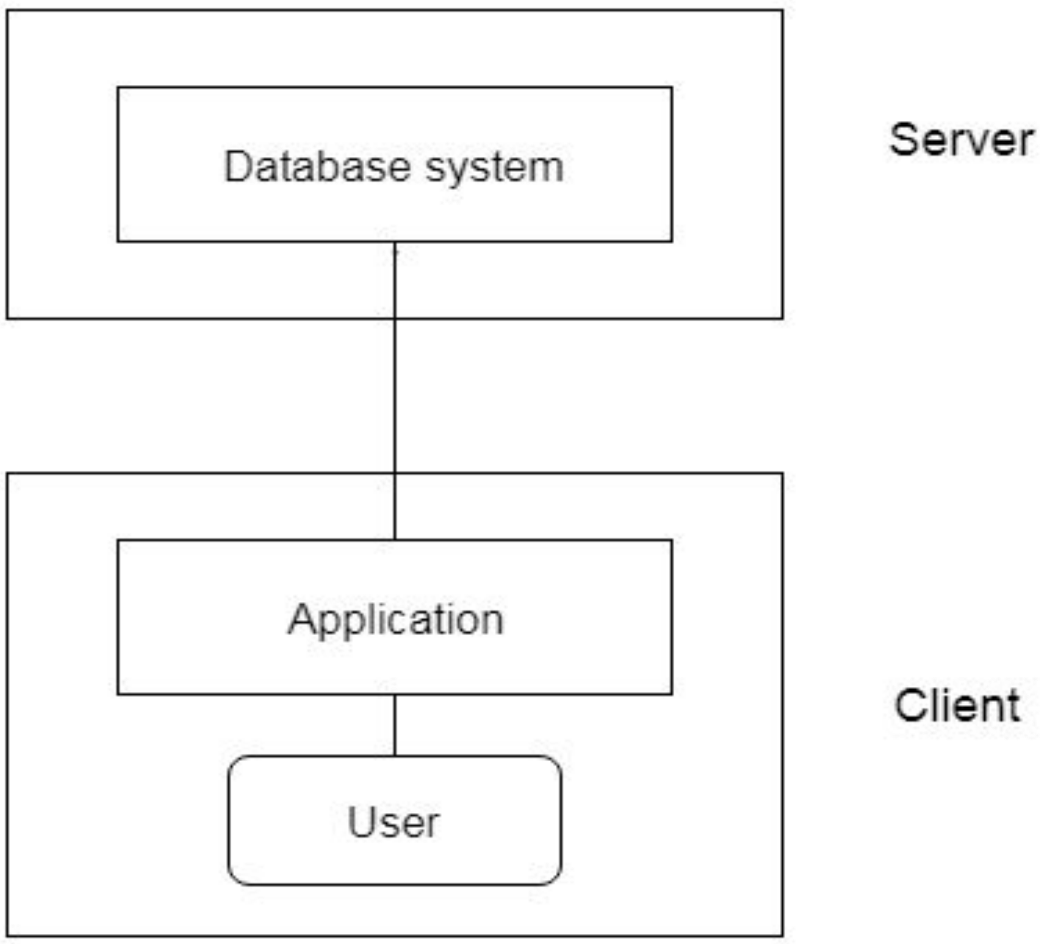
DBMS Architecture



1) 1-Tire 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.

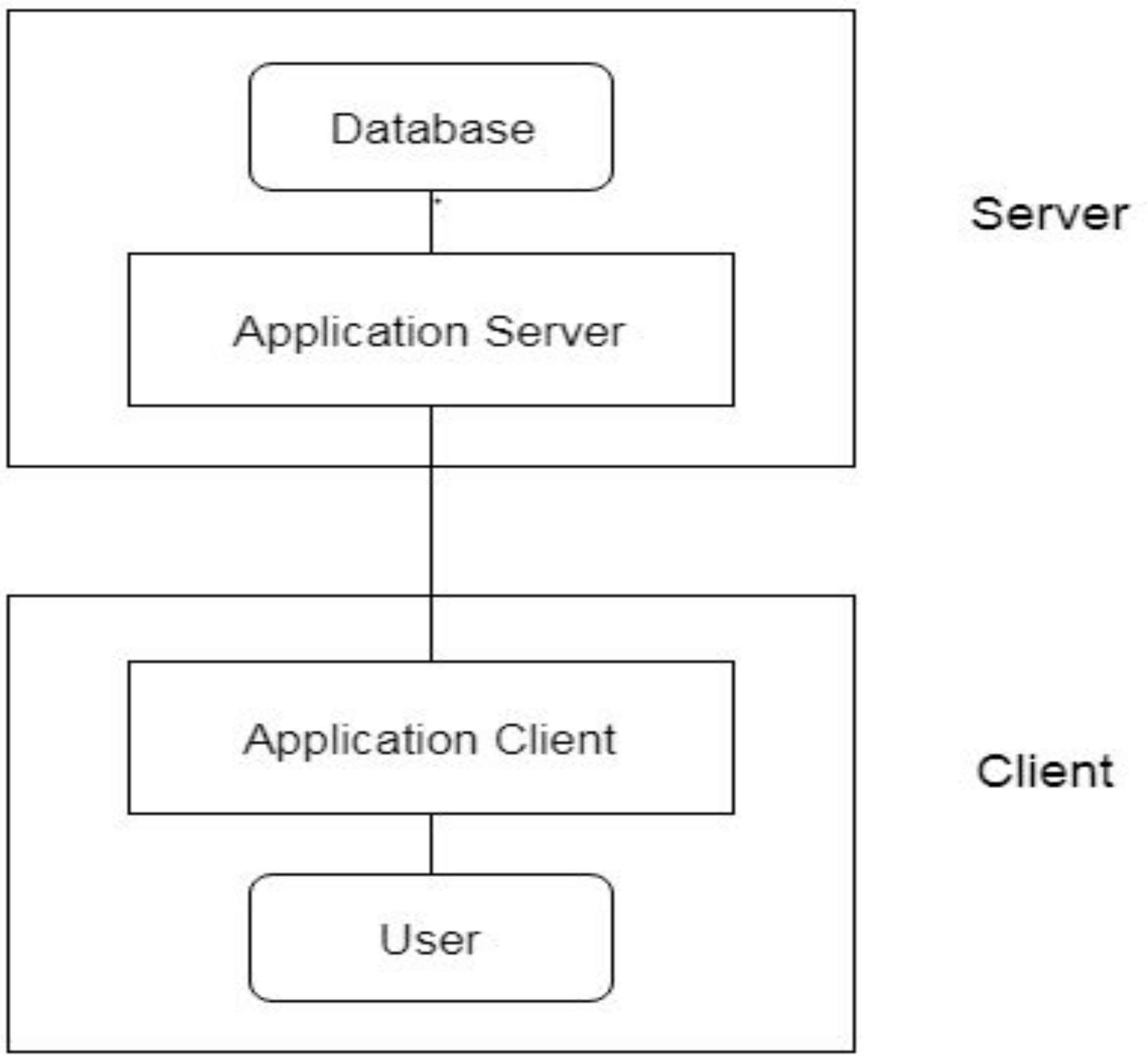
2) 2-Tire Architecture



Cont..

- 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**(Open database connectivity), **JDBC**(Java database connectivity)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.

3) 3-Tire Architecture

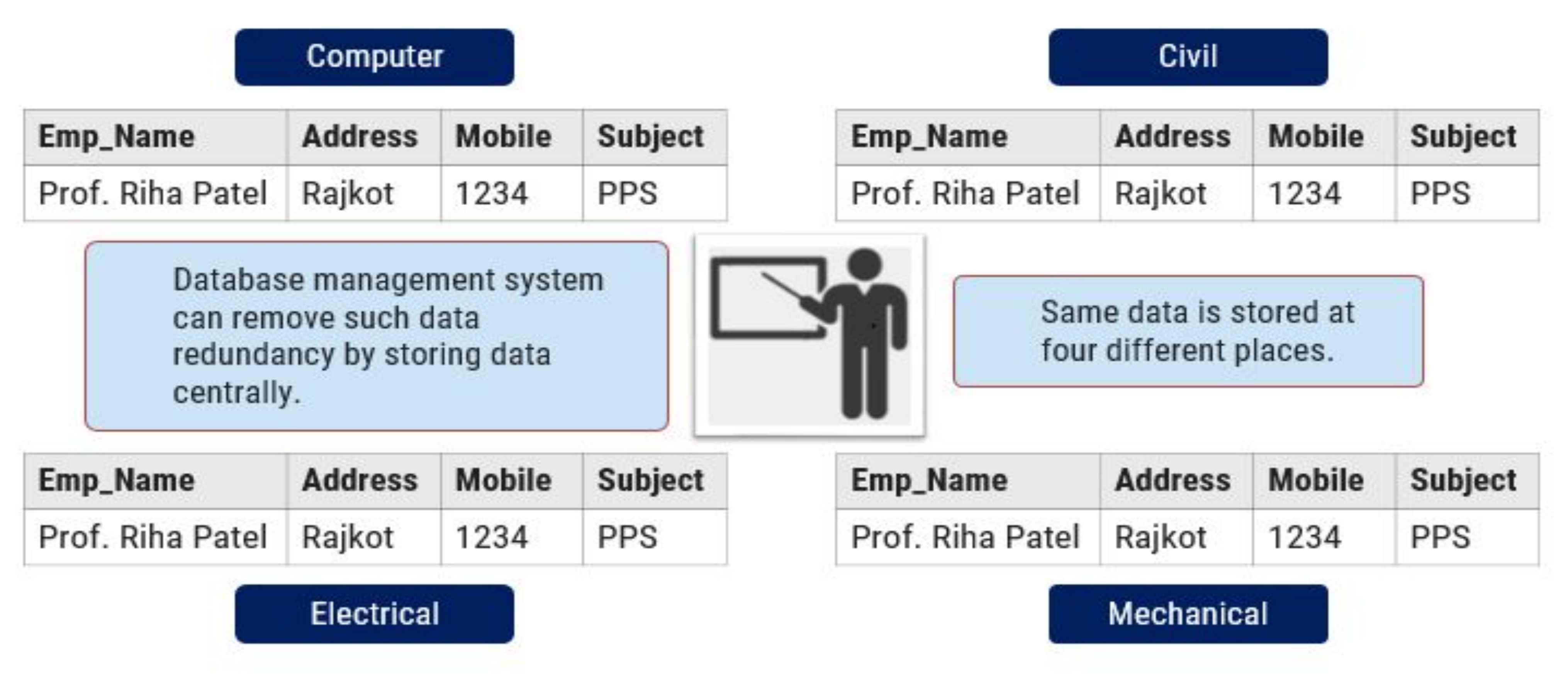


Cont..

- 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.

Advantages of DBMS

1) Reduce data redundancy (duplication)



Computer

Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

Civil

Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

Database management system can remove such data redundancy by storing data centrally.

Same data is stored at four different places.

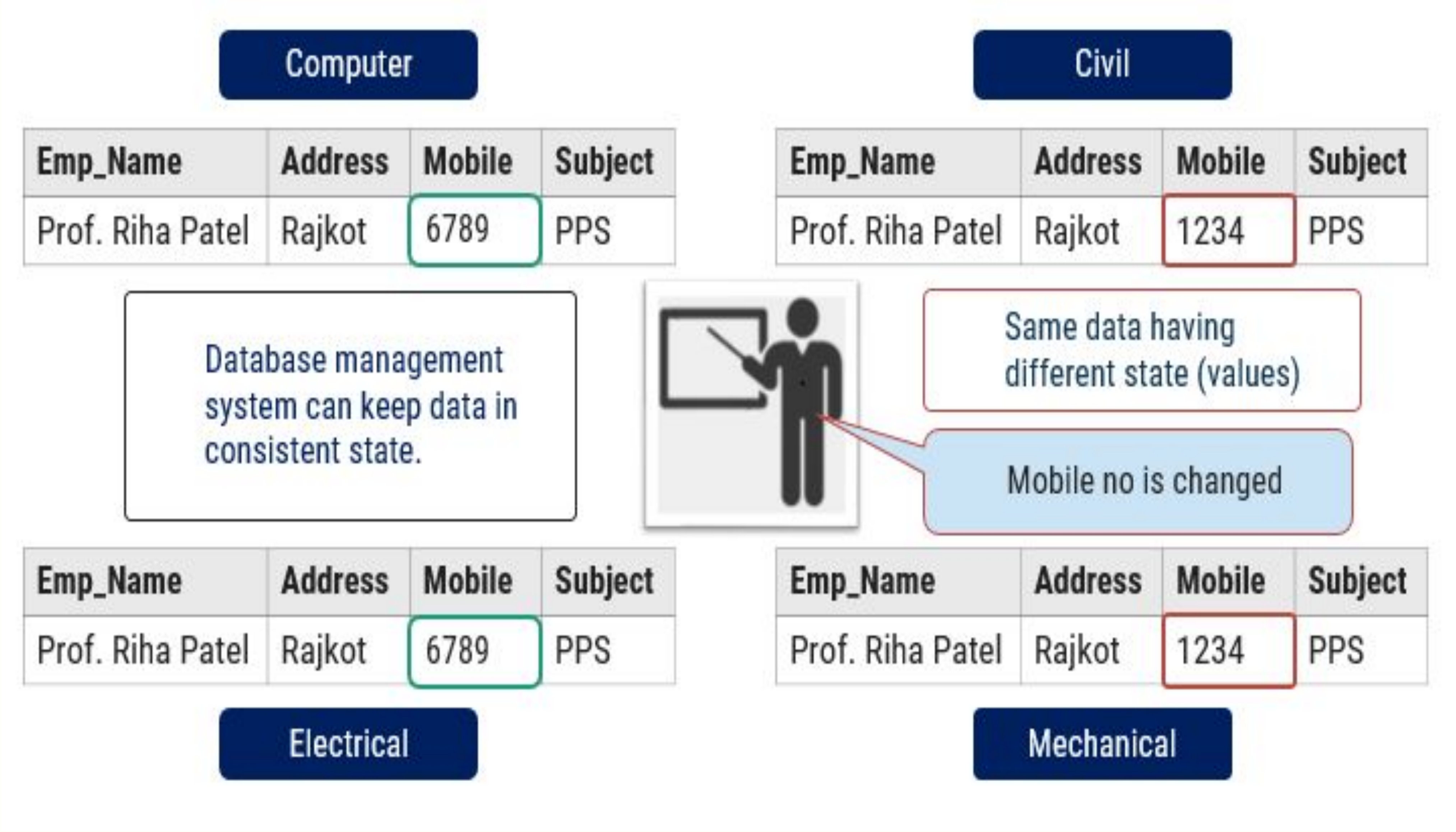
Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

Electrical

Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

Mechanical

2) Remove data inconsistency



Computer

Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	6789	PPS

Civil

Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

Database management system can keep data in consistent state.

Same data having different state (values)

Mobile no is changed

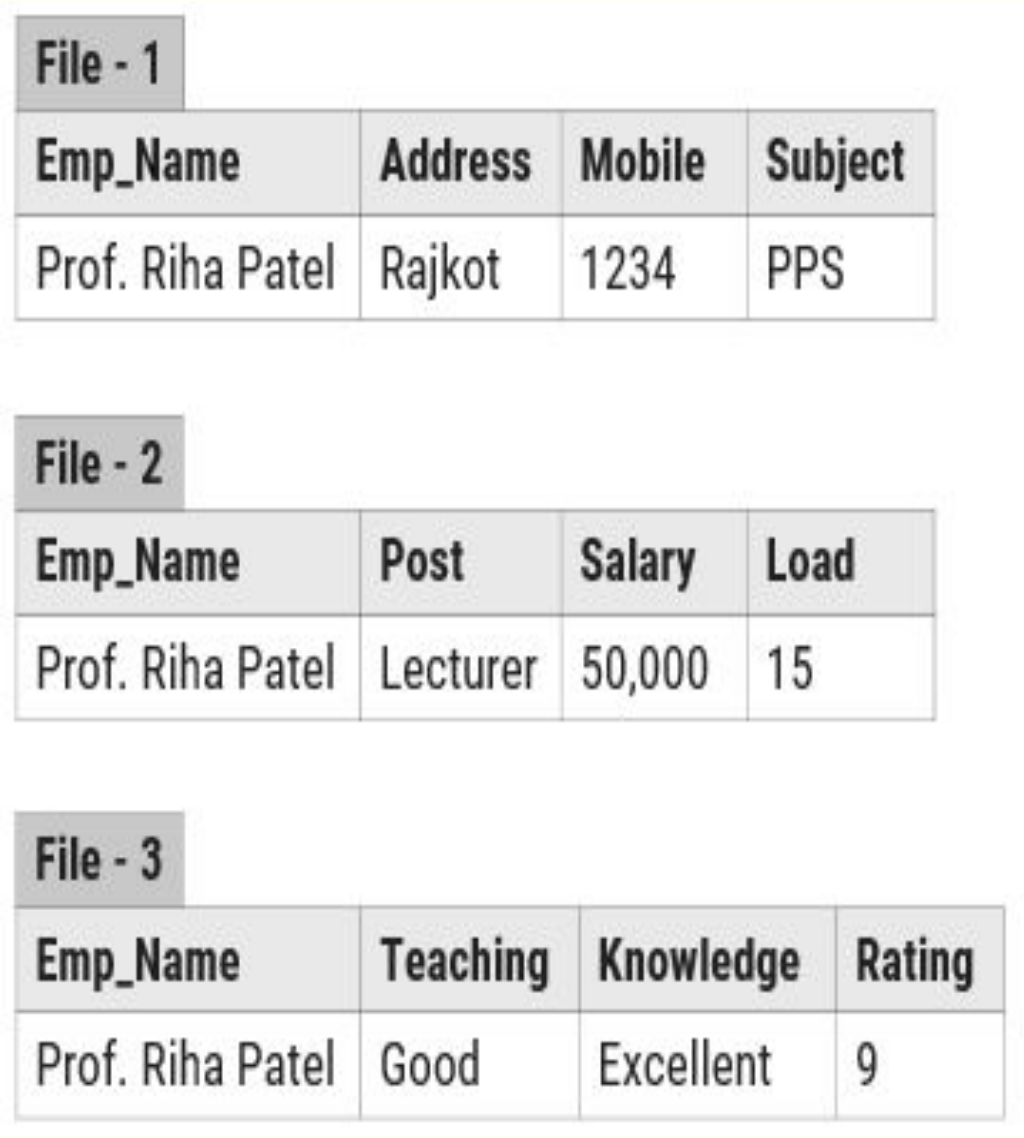
Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	6789	PPS

Electrical

Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

Mechanical

3) Data isolation



File - 1

Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

File - 2

Emp_Name	Post	Salary	Load
Prof. Riha Patel	Lecturer	50,000	15

File - 3

Emp_Name	Teaching	Knowledge	Rating
Prof. Riha Patel	Good	Excellent	9

❑ Data are **scattered** in various files.

❑ Files may be in **different formats**.

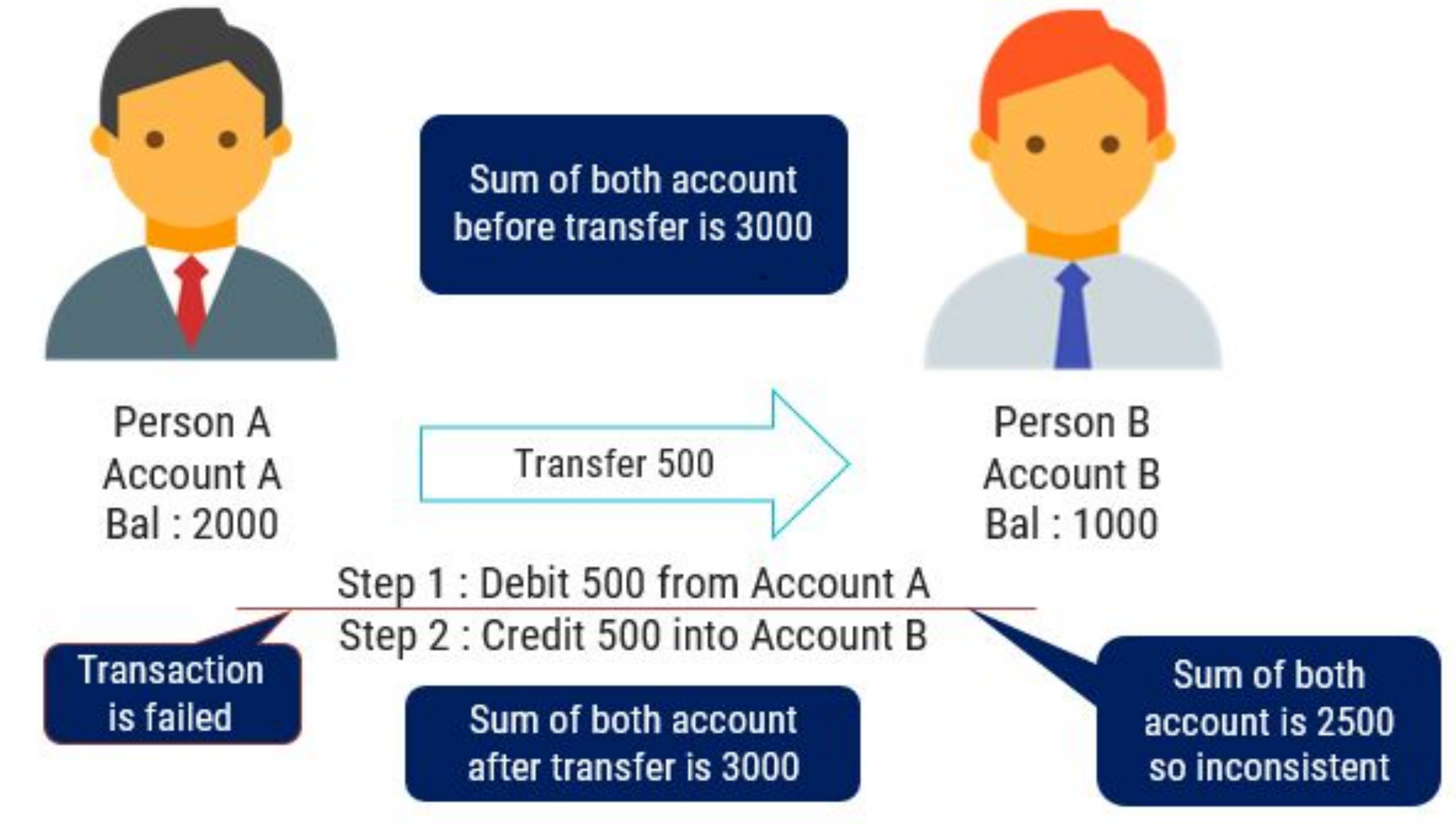
❑ **Difficult to retrieve** the appropriate data.

DBMS allow us to access (retrieve) appropriate data easily.

Data isolation is a property that determines when and how changes made by one operation become visible to other concurrent users and systems.
This issue occurs in a concurrency situation.

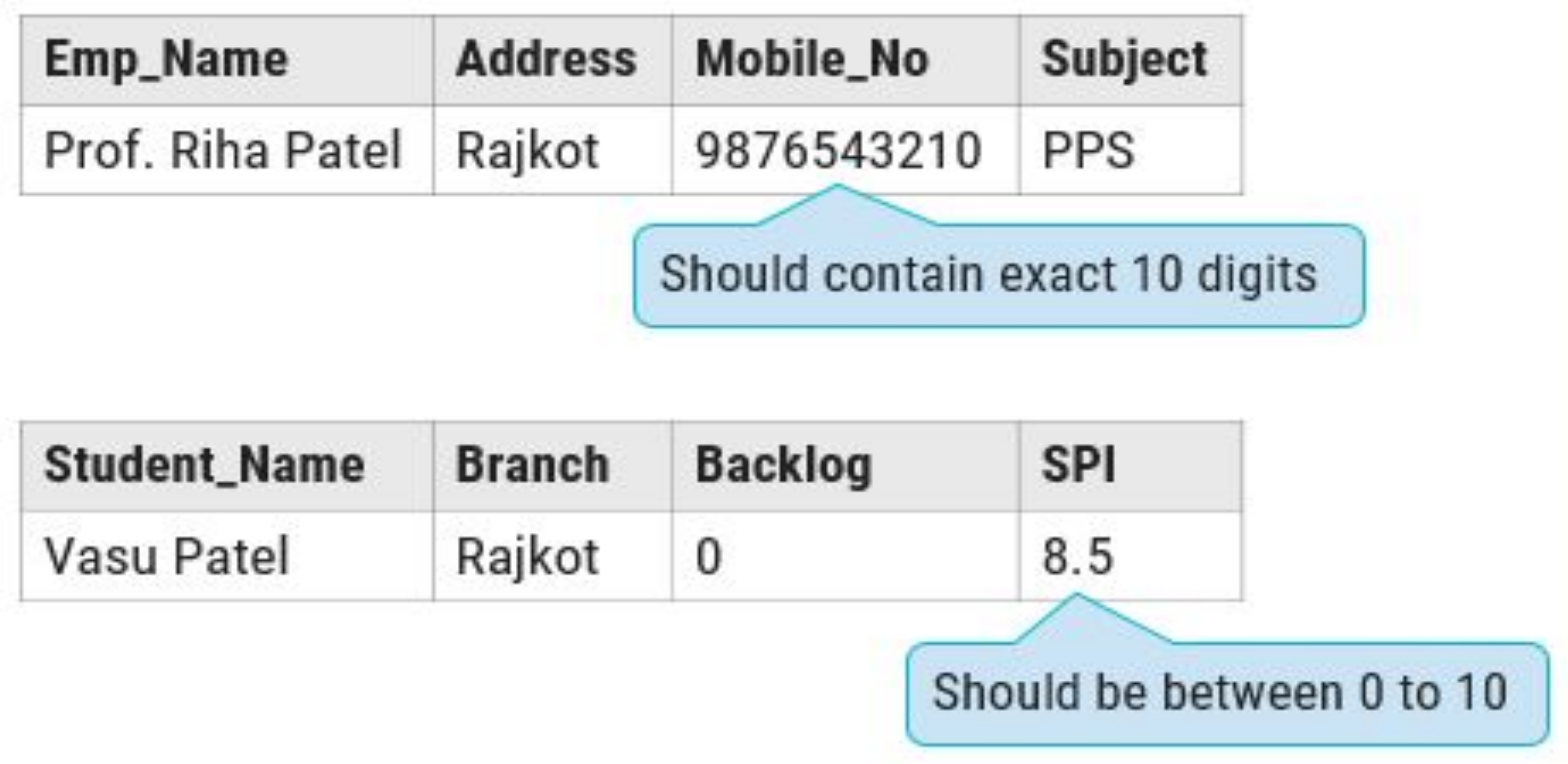
4) Guaranteed atomicity

Atomicity: Either transaction **execute 0% or 100%**.



Sum of both account before transfer is 3000
Person A
Account A
Bal : 2000
Transfer 500
Person B
Account B
Bal : 1000
Step 1 : Debit 500 from Account A
Step 2 : Credit 500 into Account B
Transaction is failed
Sum of both account after transfer is 3000
Sum of both account is 2500 so inconsistent

5) Allow to implement integrity constraints



Emp_Name	Address	Mobile_No	Subject
Prof. Riha Patel	Rajkot	9876543210	PPS

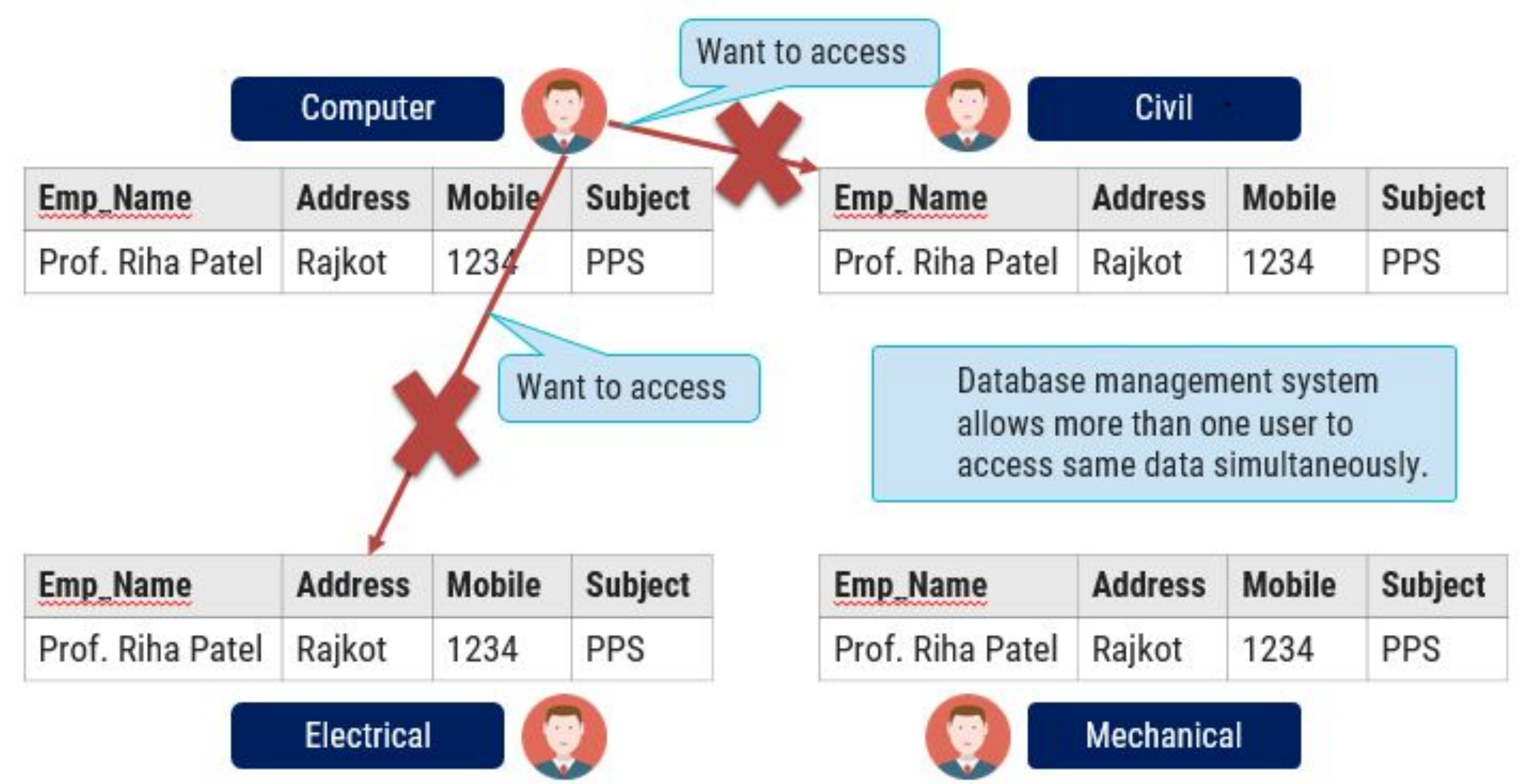
Should contain exact 10 digits

Student_Name	Branch	Backlog	SPI
Vasu Patel	Rajkot	0	8.5

Should be between 0 to 10

DBMS allows us to implement such business rules in our database..

6) Sharing of data among multiple users



Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

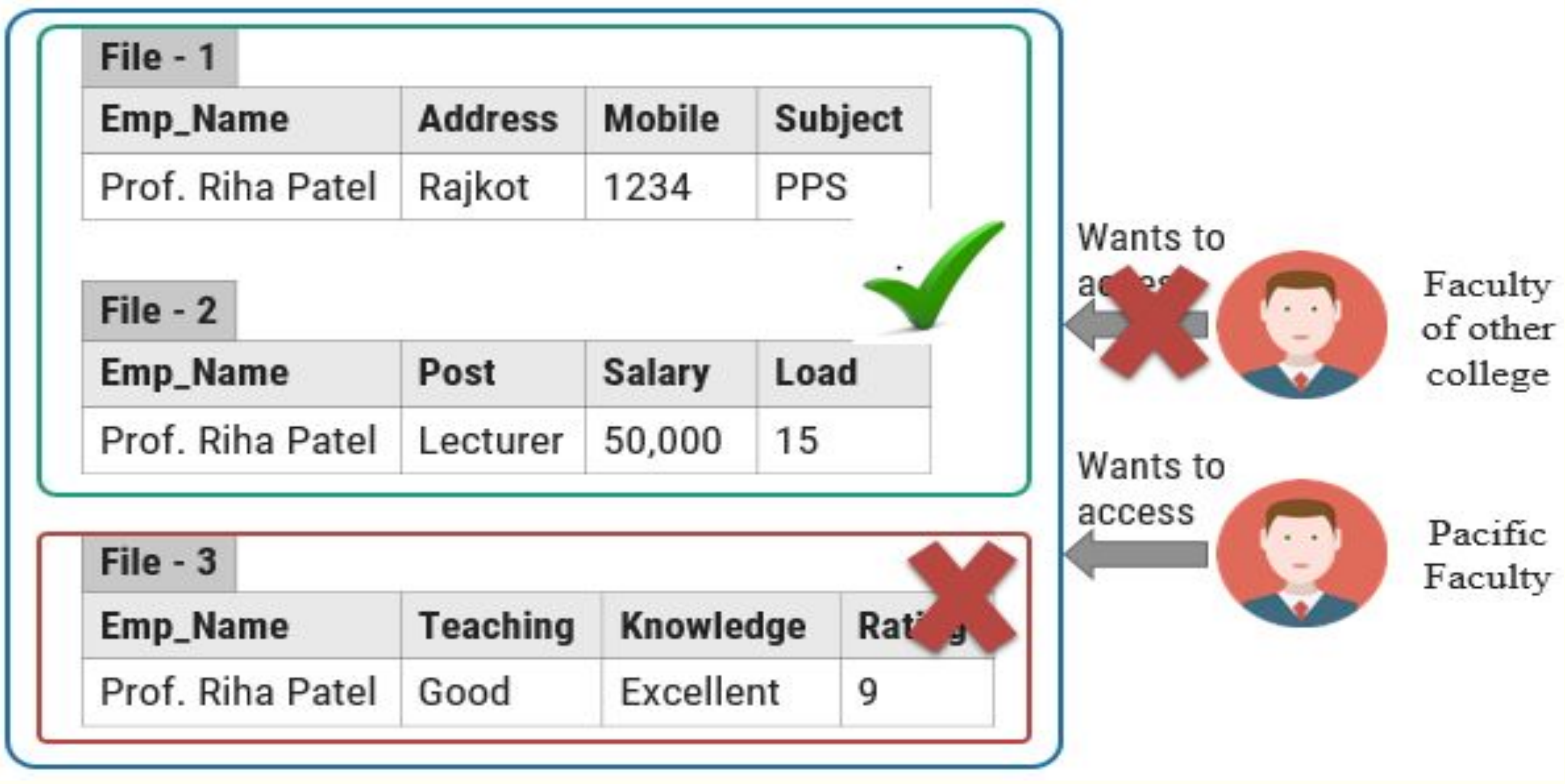
Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

Database management system allows more than one user to access same data simultaneously.

Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

7) Restricting unauthorized access to data



File - 1

Emp_Name	Address	Mobile	Subject
Prof. Riha Patel	Rajkot	1234	PPS

File - 2

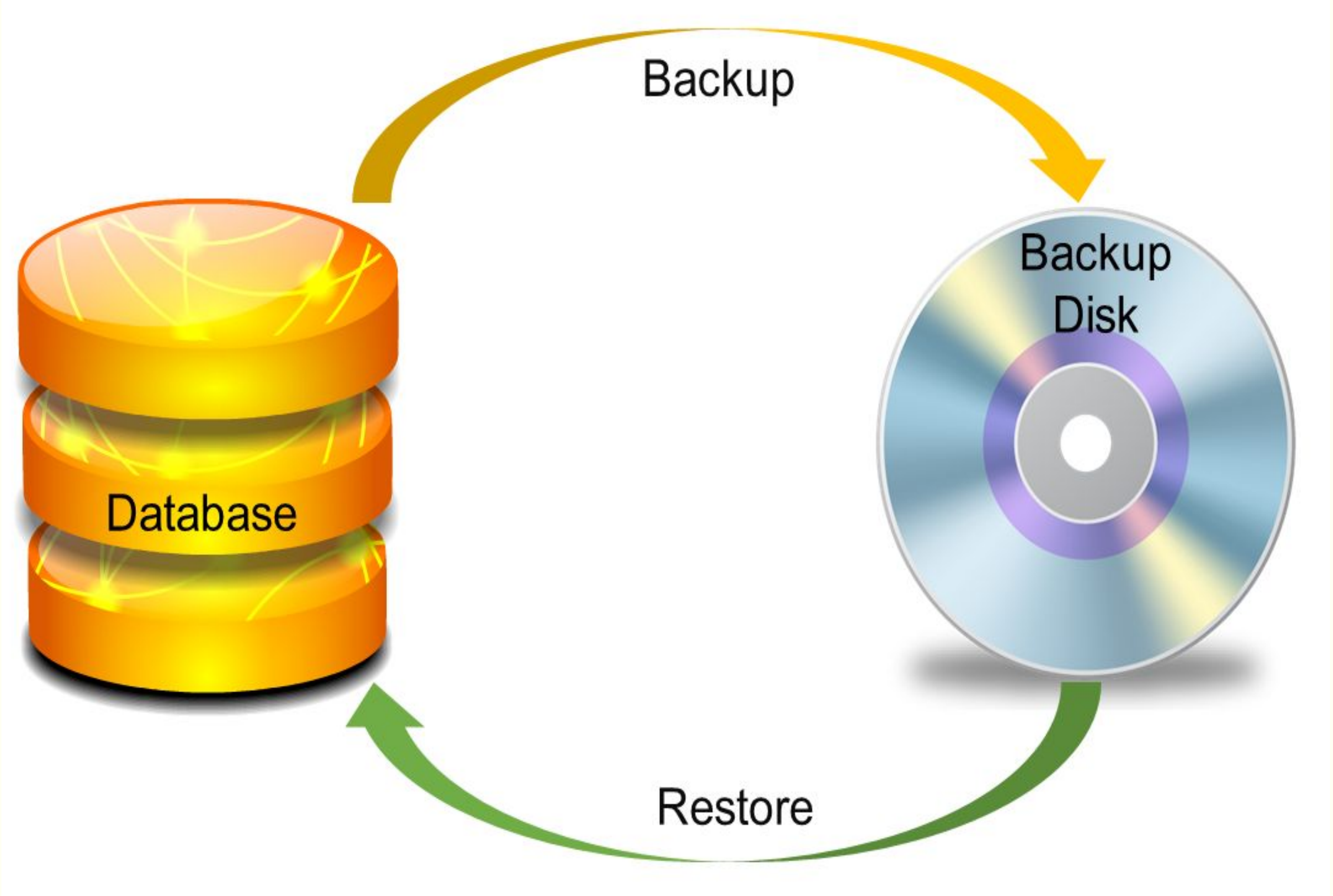
Emp_Name	Post	Salary	Load
Prof. Riha Patel	Lecturer	50,000	15

File - 3

Emp_Name	Teaching	Knowledge	Rating
Prof. Riha Patel	Good	Excellent	9

DBMS prevents unauthorized user to access data.

8) Providing backup and recovery services



Provides facilities to backup and restore the database in case of failure.

DBMS Advantages(Summary)

- Reduce data redundancy (duplication)
  - **Avoids unnecessary duplication** of data by storing data centrally.
- Remove data inconsistency
  - By **eliminating redundancy**, data **inconsistency can be removed**.
- Data isolation
  - A user can **easily retrieve proper data** as per his/her requirement.
- Guaranteed atomicity
  - Either transaction **executes 0% or 100%.**

DBMS Advantages(Summary)

- Allow implementing integrity constraints
    - **Business rules can be implemented** such as do not allow to store amount less than Rs. 0 in balance.
- Sharing of data among multiple users
    - **More than one users can access** same data at the same time.
- Restricting unauthorized access to data
    - A user can **only access data which is authorized** to him/her.
- Providing backup and recovery services
    - Can **take a regular auto or manual backup** and **use it to restore** the database if it corrupts.

Questions asked in GTU

1. List and explain the advantages of DBMS over file based system.
2. Draw and explain 3 level architecture of DBMS.
3. List and explain different categories/types of database users.
4. List and explain different tasks/roles/functions/duties of DBA (Database Administrator).
5. Explain DBMS architecture with block diagram. **OR** Explain Database System architecture with block diagram.

Thank You…