Chapter: Introduction to Database

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Course Info

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Books and Materials

- Reference books:

Abraham Silberschatz, Henry F Korth and S. Sudarshan, Database System Concepts 6th Edition, 2011:Tata McGraw-Hill

Lecture Materials:

- Lecture Slides
- Additional readings

Course Evaluation Plan: Tentative

- Mid-Sem:15%
- End-Sem:45%
- Assignments:20%
- Attendance:5%
- SQL Lab:15%

Course Syllabus: Tentative

- Introduction
- E.R Model
- Relational Database Design
- Formal Relational Query Language
- Transaction management
- Concurrency Control
- Database Recovery
- Indexing and Hashing

Introduction

What is What?

- Data
  - Set of values representing some information.
  - Ex: age is 21 years, blue shirt, today’s temp. is 30°C
  - Salary of ₹20,000, height of john 6’2”, . . .
- Database (DB)
  - Is a collection of interrelated data (pertaining to one organization or business house) organized in a meaningful way.
- Database Management System (DBMS)
  - Is a collection of interrelated data and a set of programs to store/retrieve those data.

DBMS Package

- A software **package** designed to define, manipulate, retrieve and manage data in a database in a user friendly environment

MySQL
Microsoft SQL Server
Microsoft Access
PostgreSQL
Firebird
ORACLE
SQLite

Database Management System (DBMS)

- DBMS contains information about a particular enterprise
  - Collection of ***interrelated data***
  - ***Set of programs*** to access the data
  - An ***environment*** that is both *convenient* and *efficient* to use

Applications

- Database Applications:
  - Banking: transactions
  - Airlines: reservations, schedules
  - Universities: registration, grades
  - Sales: customers, products, purchases
  - Online retailers: order tracking, customized recommendations
  - Manufacturing: production, inventory, orders, supply chain
  - Human resources: employee records, salaries, tax deductions
  - . . .
- Databases can be very large
- Databases touch all aspects of our lives

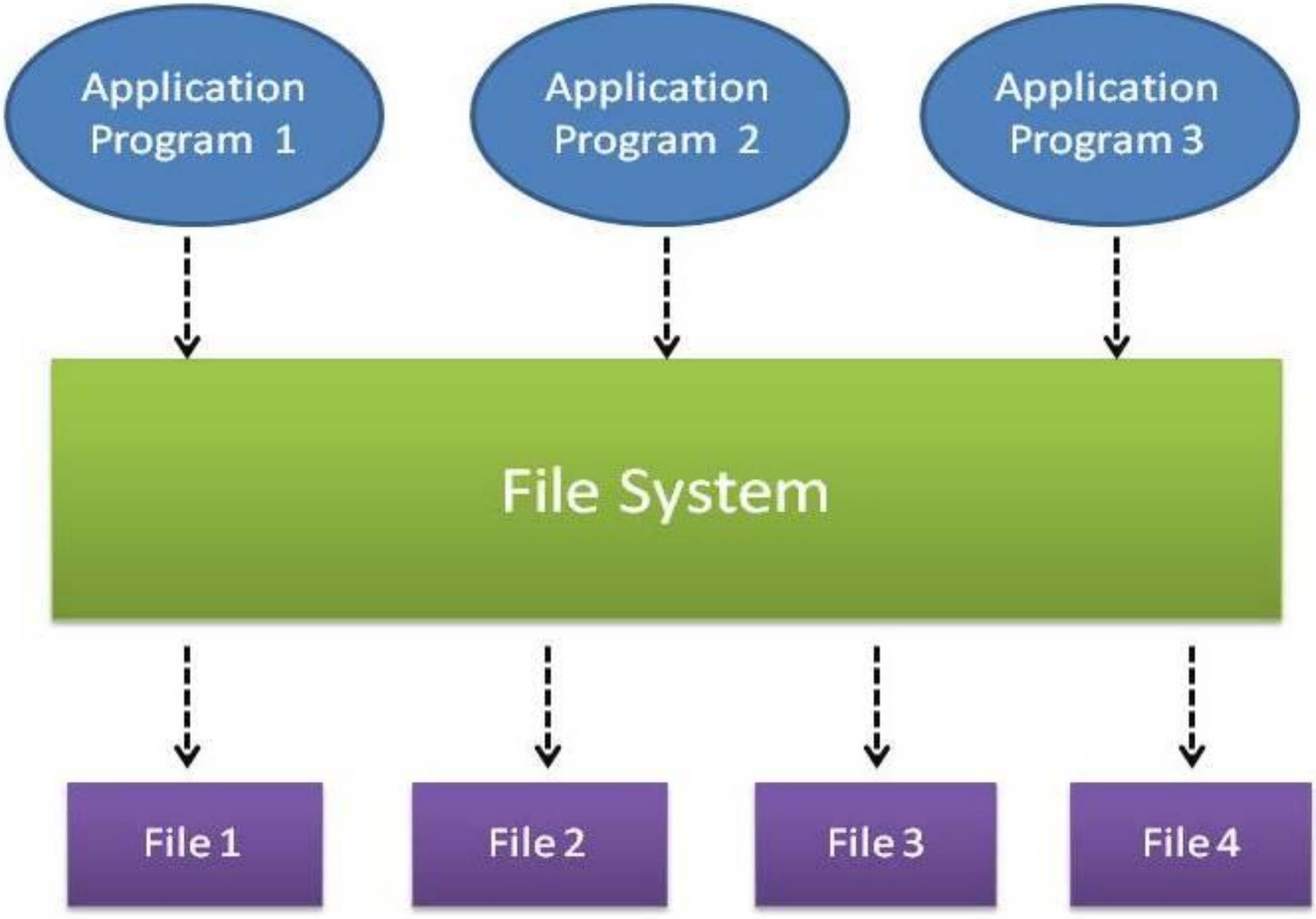
Database Use

- In early days, people used to interact with the database indirectly
  - Printed reports such as credit card statements, bank teller, reservation agents
- Currently, people interact with the database directly
  - ATM
  - E-Shopping
  - E-Banking
  - E-Application

University Database Example

- Application program examples
  - Add new students, instructors, and courses
  - Register students for courses, and generate class rosters
  - Assign grades to students, compute grade point averages (GPA) and generate transcripts
- In the early days, database applications were built directly on top of file systems

Traditional Approach-file system



Drawbacks of using file systems-I

- Data redundancy and inconsistency
  - Multiple file formats: due to multiple programmers over a period of time.
  - Duplication of information in different files: A student record (name , regno, address, …) is maintained in CSIT, Maths, Phy, ECE depts.
  - If address info is changed but not reflected every where, then data becomes inconsistent.
- Difficulty in accessing data
  - Need to write a new program to carry out each new task
  - Ex: find students from out side odisha?

Drawbacks of using file systems-II

- Data isolation
  - Data scattered in various files possibly of different formats. Writing application program to retrieve required data becomes impossible.
- Integrity problems
  - Integrity constraints are in program code rather than being stated explicitly with data e.g.,
    - account balance > 0
    - Reg No can't be blank
    - Age can't be a negative number
    - etc.
  - Hard to add new constraints or change existing ones as it needs application program modification.

Drawbacks of using file systems-III

- Atomicity problems (of updates)
  - Failures may cause an inconsistent state with partial updates carried out.
  - Ex: Transfer of funds from one account to another should either complete or not happen at all (debited but not credited)
- Concurrent access anomalies (by multiple users)
  - Concurrent access needed for performance
  - Uncontrolled concurrent accesses can lead to inconsistencies
    - Example: Two people reading a balance (say 100) and updating it by withdrawing money (say 50 each) at the same time
- Security problems
  - Hard to provide user access to some, but not all, data
  - i.e. defining user roles

Database systems offer solutions to all the above problems

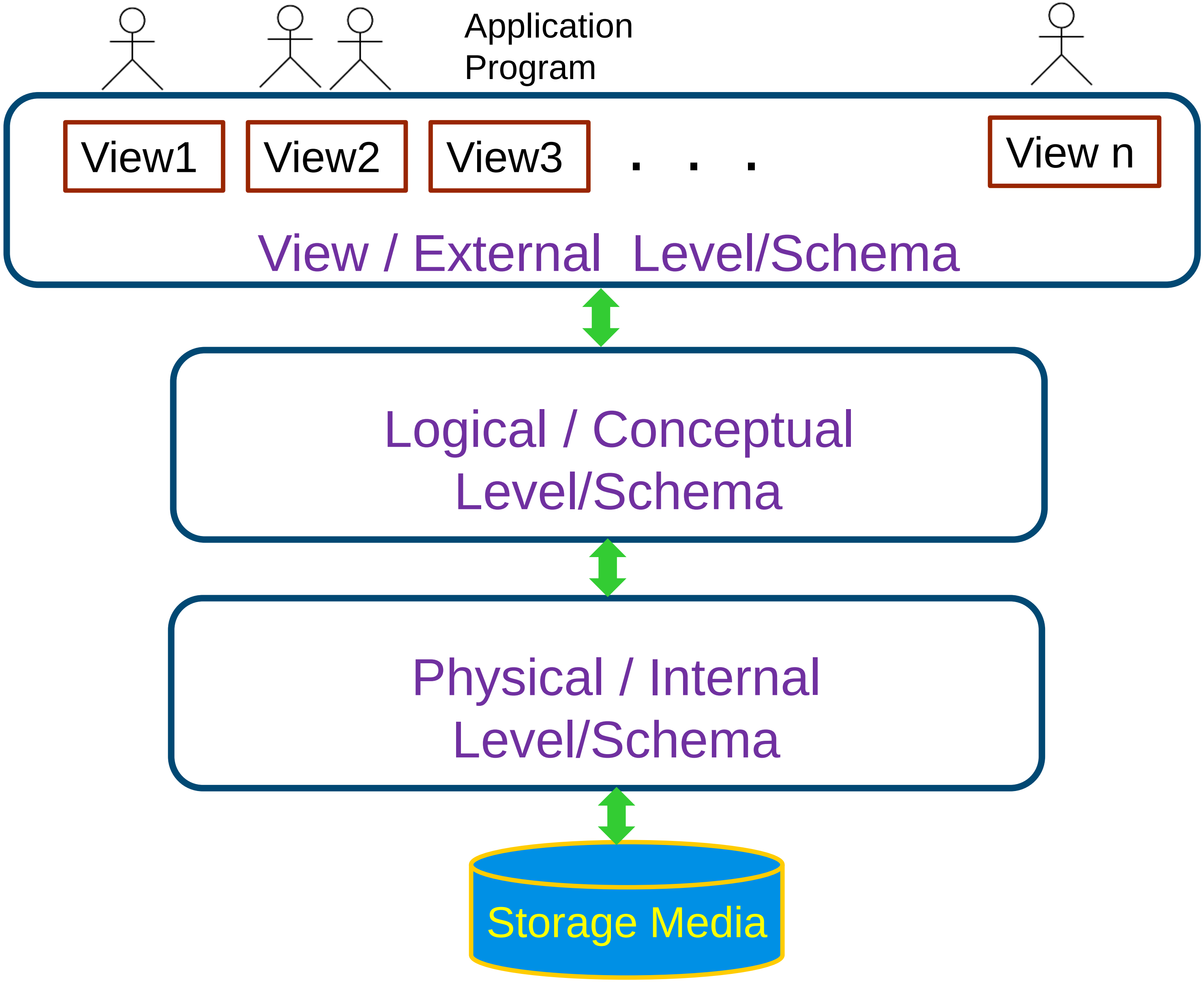
Data Abstraction

- A major purpose of database system is to provide users with an abstract view of the data.
- That is the system hides certain details how the data are stored and maintained.
- The abstraction helps avoiding mishandling of data by normal database users and makes it simple and
- Makes it convenient to access and understand the information

Example Abstraction

- Map
  - is an abstraction of a geographical region (easy to understand the world)
- Riding a bike
  - No abstraction: Read and understand the mechanism of IC engine, gear mechanism, brake system, electrical section . . .
  - Abstraction: Understand only the use of accelerator, gear and brake leavers. (life is simple)

Three Schema architecture of DBMS



Application Program

View1

View2

View3

. . .

View n

View / External Level/Schema

Logical / Conceptual Level/Schema

Physical / Internal Level/Schema

Storage Media

Data abstraction in Database

- Database system provide three different levels of abstraction
- **Physical level / Internal Schema**:
  - The lowest level that describes how data are actually stored.
  - It describes the complex low-level data structures in detail.
  - Used by package developers

Levels of Abstraction

- **Logical level / Conceptual Schema:** describes what data are stored in database, and the relationships among the data.

```
type instructor = record
        ID : string;
        name : string;
        dept_name : string;
        salary : integer;
    end;
```

- Deals with simple structures (tables) to store database information.
- Database administrators use this abstraction without knowing the details of complex physical structure called physical data independence.

Levels of Abstraction

- **View level / External Schema:** highest level of abstraction that presents a specific portion of the database view for different users.
- This level may contain many different views of the database required by different users.
- All these views are mapped on a single unified conceptual level.
- Application programs hide details of data types. Views can also hide information (such as an employee's salary) for security purposes.
- User access layer that is used to simplify the interaction between a user and the database.

Instances and Schemas

- **Database Instance** (variables values)
  - The collection of database information at a given time is called the instance of the database of that time. (Actual content of the database)
  - Ex: Reg: 001, Name: john, Branch: CSIT, Sem: 4, . . .
  - With database operations like, insertion, deletion, updation, the instance changes
  - Ex: Reg: 001, Name: john, Branch: CSIT, Sem: 5, . . .
  - Reg: 002, Name: Smith, Branch: CSIT, Sem: 5, . . .
- **Database Schema** (types, variables)
  - It refers to the overall design of the database
  - Depending upon the level of abstraction, there exists 3 types of database schemas

Three level Schemas

- **Physical schema**– the overall physical structure of the database
- **Logical Schema** – the overall logical structure of the database
  - Ex: The database consists of information about a set of customers and accounts in a bank and the relationship between them
    - Analogous to type information of a variable in a program
- **External Schema / View** – At the external level, we find multiple views of the database referred as sub-schemas
- Schema changes infrequently than instances.

Data Independence

- **Data Independence** – Any changes made to the lower-level schema does not affect the higher level schema.
- **Physical Data Independence** – the ability to modify the physical schema without changing the logical schema
  - Applications depend on the logical schema
  - In general, the interfaces between the various levels and components should be well defined so that changes in some parts do not seriously influence others.
- **Logical Data Independence** – Any change made to the conceptual level schema, do not require any change modification to the external schema.

Database Language

- The language used for database is broadly classified into two categories of languages.
- **Data Definition Language (DDL)**– basically used for defining/modifying the logical schema.
- **Data Manipulation Language (DML)** – used to access and manipulate the database instance.
- In practice, these are not two separate languages, rather they are the two parts of the same commercial database language called Structural Query Language (SQL)
- That is SQL integrates all

Data Definition Language (DDL)

- Specification notation for defining the database schema (create, alter, drop, rename, ...)

  Example: **create table** *instructor* (

  ```
  ID          char(5),
  name        varchar(20),
  dept_name   varchar(20),
  salary      numeric(8,2))
  ```

- DDL compiler generates a set of table templates stored in a ***data dictionary***
- Data dictionary contains metadata (i.e., data about data)
  - Database schema
  - Integrity constraints
    - Primary key (ID uniquely identifies instructors)
  - Authorization
    - Who can access what

Data Manipulation Language (DML)

- Language for accessing and manipulating the data organized by the appropriate data model
  - DML also known as query language
  - Operations supported: insert, delete, update, retrieve
- Two classes of languages
  - **Pure** – used for proving properties about computational power and for optimization
    - Relational Algebra
    - Tuple relational calculus
    - Domain relational calculus
  - **Commercial** – used in commercial systems
    - SQL is the most widely used commercial language

DML-II

- DML can be of two types
- **Procedural DML**: Requires user to specify what data are needed and how to get those data?
- **Declarative / non-procedural DML**: Requires user to specify what data are needed? without specifying how to get those data.
  - It is easy to use and popular
  - When DML is executed, the meta data present in the data dictionary are referred to check the validity of the intended DML operation.

Database Users

- **Naive users**
  - The don’t have much knowledge on databases
- **Application Programmers**
  - Those have developed the application.
- **Sophisticated users**
  - They are not direct users, they are analyst, knowledge workers.
- **Specialized users** (Database administrators)
  - One of the primary objective of database system is to have centralized control over the entire database and the application programmes. It is achieved by database administrators.

Database Administrators (DBA)

- DBA may be a person or a group of persons in an organization acts as the manager of the database and take full responsibility of the database of that organization.
- The important roles and responsibilities of DBA are
  - Defining the Database schema
  - Defining the storage structure and access methodology
  - Modifying the database schema and storage organization
  - Granting authorization and ensuring security
  - Monitoring the database performance
  - Routine maintenance of database

Data Model

- A collection of conceptual tools for describing
  - Data
  - Data relationships
  - Data semantics
  - Data constraints
- The data models can be classified into following four different categories
  - Relational model
  - Entity-Relationship data model (mainly for database design)
  - Object-based data models (Object-oriented and Object-relational)
  - Semi-structured data model (XML)
  - Other older models:
    - Network model
    - Hierarchical model

End of Chapter

Thank You