Database Management System

Fundamental Database Concepts

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- Purpose of DBMS
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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

DBMS is a software (i.e. programs along with environment) which manages interrelated data about a particular enterprise.

Database Management System (DBMS)

- Data is facts/ information.
- A database is any collection of data.
- A DBMS is a software system designed to maintain a database.
- A Database Management System (DBMS) is a software package designed to store and manage databases.

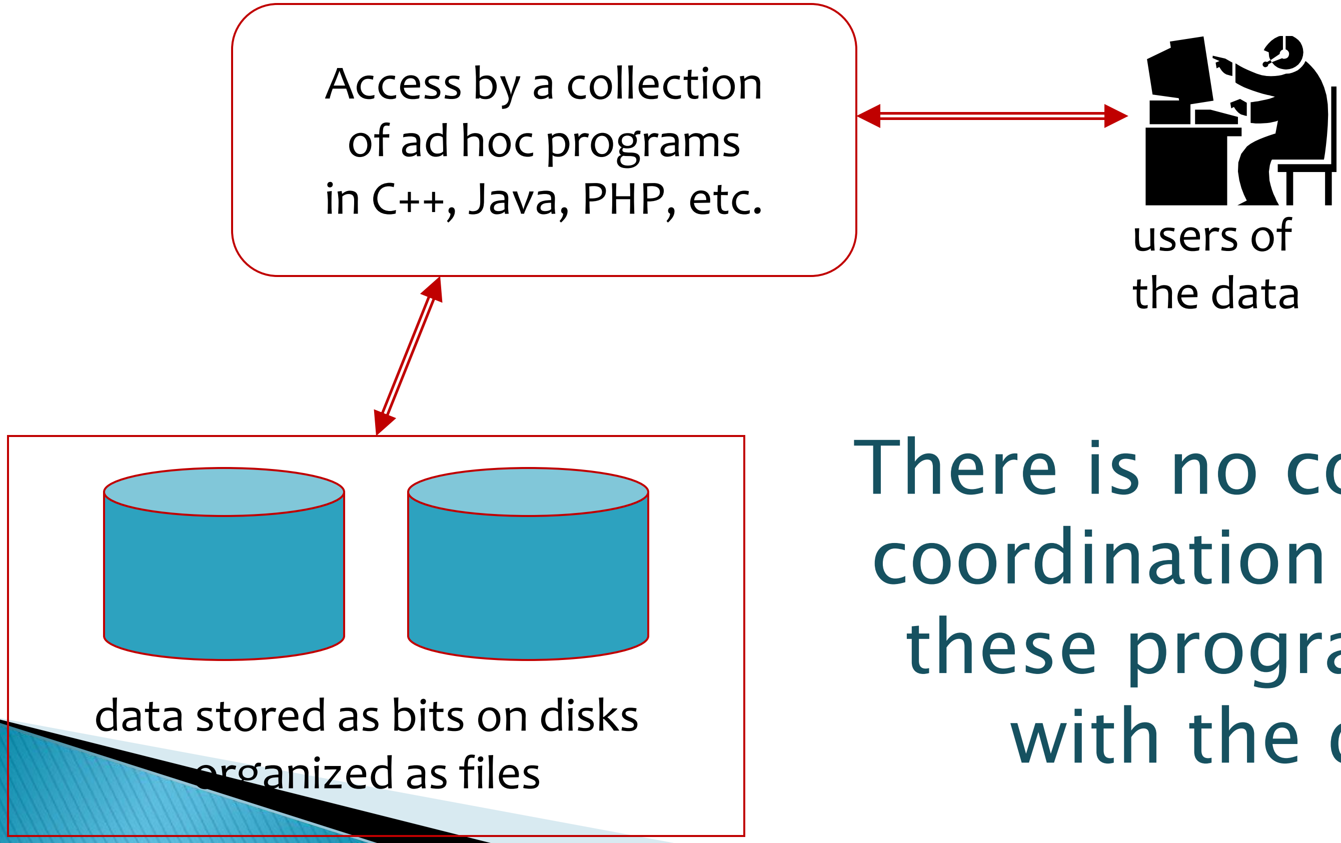
- We use a DBMS when
  - there is a large amount of data
  - security and integrity of the data are important
  - many users access the data concurrently

Basic Definitions

- **Database**: A collection of related data.
- **Data**: Known facts that can be recorded and have an implicit meaning.
- **Mini-world**: Some part of the real world about which data is stored in a database. For example, student grades and transcripts at a university.
- **Database Management System (DBMS)**: A software package/ system to facilitate the creation and maintenance of a computerized database.
- **Database System**: The DBMS software together with the data itself. Sometimes, the applications are also included.

Why Use a DBMS?

- Without a DBMS, we'd have:



Access by a collection of ad hoc programs in C++, Java, PHP, etc.

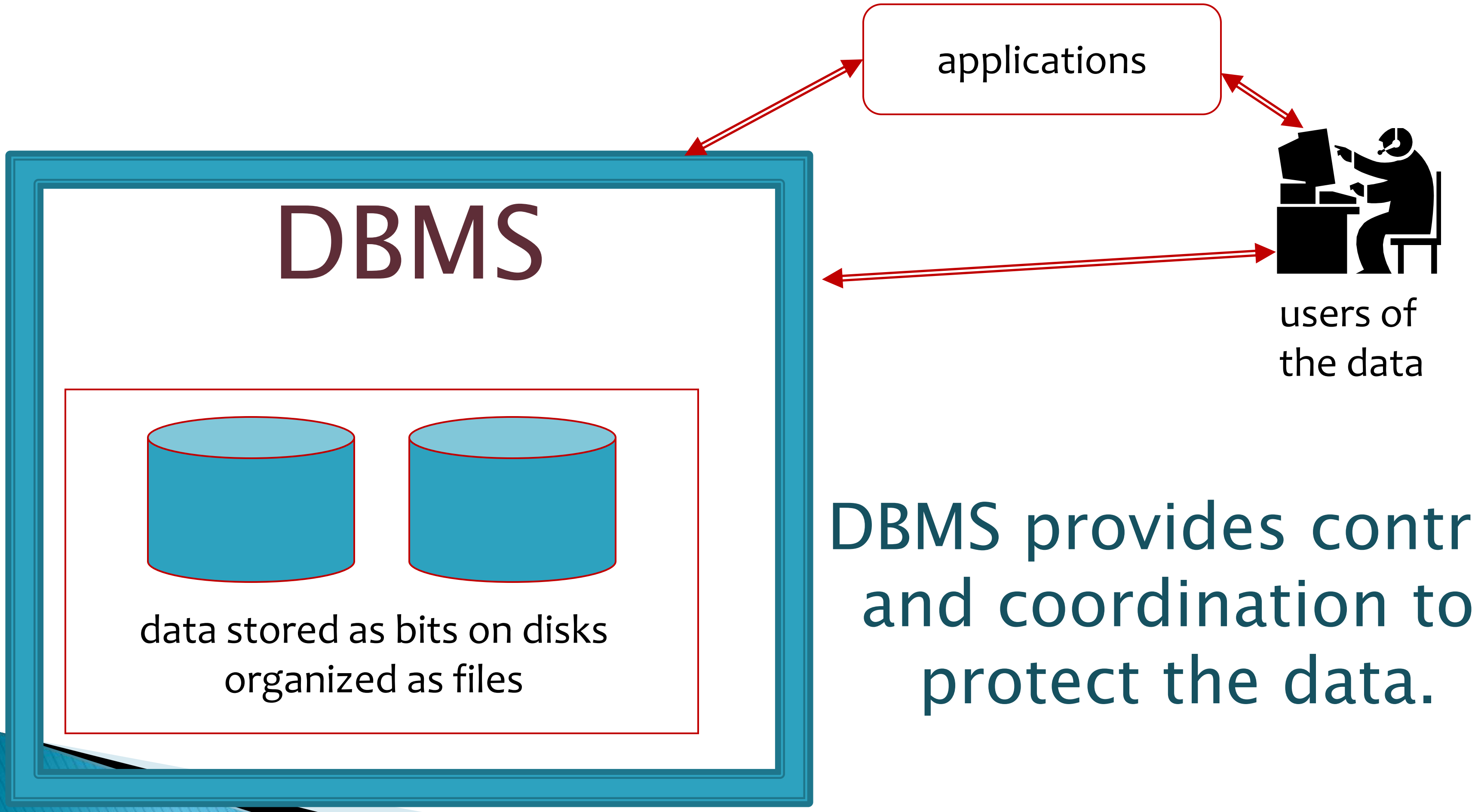
users of the data

data stored as bits on disks organized as files

There is no control or coordination of what these programs do with the data

Why Use a DBMS?

- With a DBMS, we have:



applications

DBMS

data stored as bits on disks
organized as files

users of
the data

DBMS provides control and coordination to protect the data.

Purpose of Database Systems

- In the early days, database applications were built directly on top of file systems
- Drawbacks of using file systems to store data:
  - Data redundancy and inconsistency
    - Multiple file formats, duplication of information in different files
  - Difficulty in accessing data
    - Need to write a new program to carry out each new task
  - Data isolation — multiple files and formats
  - Integrity problems
    - Integrity constraints (e.g. account balance > 0) become “buried” in program code rather than being stated explicitly
    - Hard to add new constraints or change existing ones

Purpose of Database Systems

- Drawbacks of using file systems (cont.)
  - Atomicity of updates
    - Failures may leave database in an inconsistent state with partial updates carried out
    - Example: Transfer of funds from one account to another should either complete or not happen at all
  - Concurrent access by multiple users
    - Concurrent accessed needed for performance
    - Uncontrolled concurrent accesses can lead to inconsistencies
      - Example: Two people reading a balance and updating it at the same time
  - Security problems
    - Hard to provide user access to some, but not all, data
- Database systems offer solutions to all the above problems

Typical DBMS Functionality

- **Define a database :** in terms of data types, structures and constraints
- Construct or Load the Database on a secondary storage medium
- **Manipulating the database :** querying, generating reports, insertions, deletions and modifications to its content
- Concurrent Processing and Sharing by a set of users and programs – yet, keeping all data valid and consistent

Typical DBMS Functionality

Other features:

- Protection or Security measures to prevent unauthorized access
- “Active” processing to take internal actions on data
- Presentation and Visualization of data

Main Characteristics of the Database Approach

- Self-describing nature of a database system: A DBMS **catalog** stores the *description* of the database. The description is called **meta-data**). This allows the DBMS software to work with different databases.
- Insulation between programs and data: Called **program-data independence**. Allows changing data storage structures and operations without having to change the DBMS access programs.
- Data Abstraction: A **data model** is used to hide storage details and present the users with a *conceptual view* of the database.

Main Characteristics of the Database Approach

- Support of multiple views of the data: Each user may see a different view of the database, which describes *only* the data of interest to that user.

- Sharing of data and multiuser transaction processing : allowing a set of concurrent users to retrieve and to update the database. Concurrency control within the DBMS guarantees that each **transaction** is correctly executed or completely aborted. OLTP (Online Transaction Processing) is a major part of database applications.

Applications of DBMS

- **Banking:** all 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

Levels of Abstraction

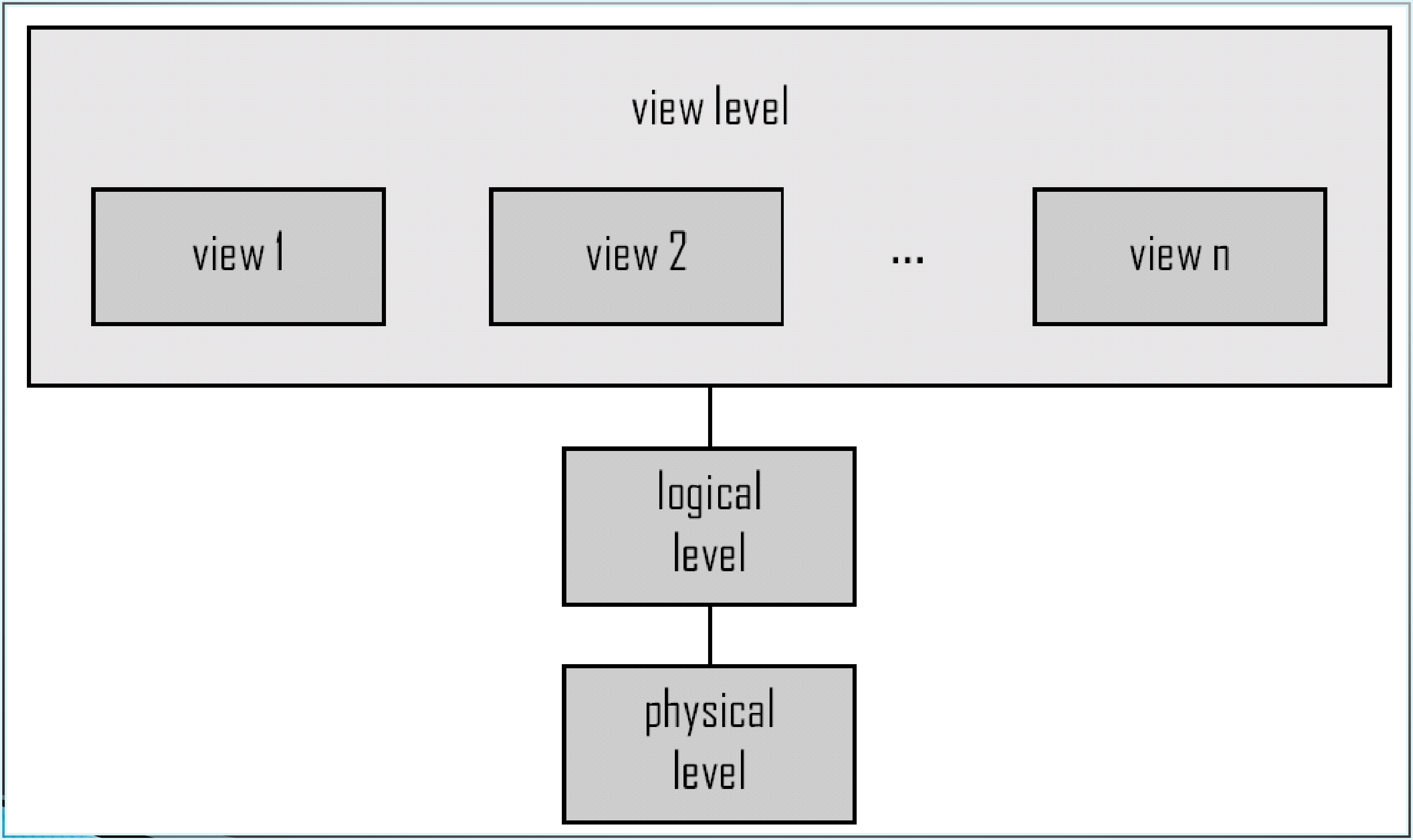
- **Physical level:** describes how a record (e.g., customer) is stored.
- **Logical level:** describes data stored in database, and the relationships among the data.

```
type customer = record
                customer_id : string;
                customer_name : string;
                customer_street : string;
                customer_city : string;
      end;
```

- **View level:** application programs hide details of data types. Views can also hide information (such as an employee's salary) for security purposes.

View of Data

An architecture for a database system



Instances and Schemas

- Similar to types and variables in programming languages
- **Schema** – the logical structure of the database

  Structural Description of the type of facts held in a database.
  - Example: The database consists of information about a set of customers and accounts and the relationship between them)
  - Analogous to type information of a variable in a program
  - **Physical schema**: database design at the physical level
  - **Logical schema**: database design at the logical level
- **Instance** – the actual content of the database at a particular point in time
  - Analogous to the value of a variable
- **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.

Data Models

- A collection of tools for describing
  - Data
  - Data relationships
  - Data semantics
  - Data constraints

There are a number of different ways of organizing a schema, i.e. of modeling a database structure, these ways are known as **Data Models**.

Types of Data Models

- Relational model
- Entity-Relationship data model (mainly for database design)
- Object-based data models (Object-oriented and Object-relational)
- Semistructured data model (XML)
- Other older models:
  - Network model
  - Hierarchical model

Data Manipulation Language (DML)

- Language for accessing and manipulating the data organized by the appropriate data model
  - DML also known as query language

- Two classes of languages
  - **Procedural** – user specifies what data is required and how to get those data (PL/SQL)
  - **Declarative (nonprocedural)** – user specifies what data is required without specifying how to get those data (SQL)

- SQL is the most widely used query language

Data Definition Language (DDL)

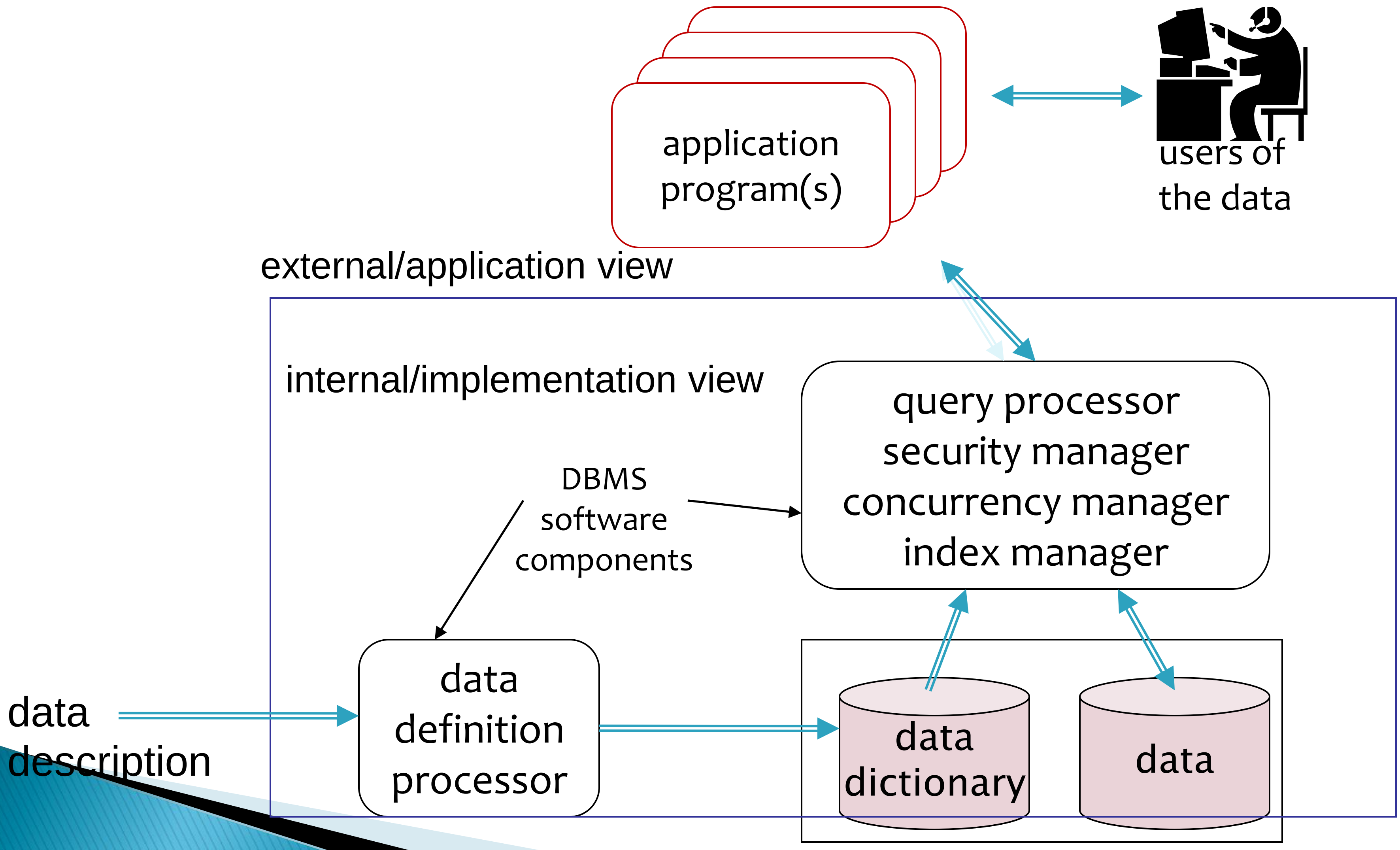
- Specification notation for defining the database schema

  Example:

  ```
  create table account (
                 account_number   char(10),
                 branch_name      char(10),
                 balance          integer)
  ```

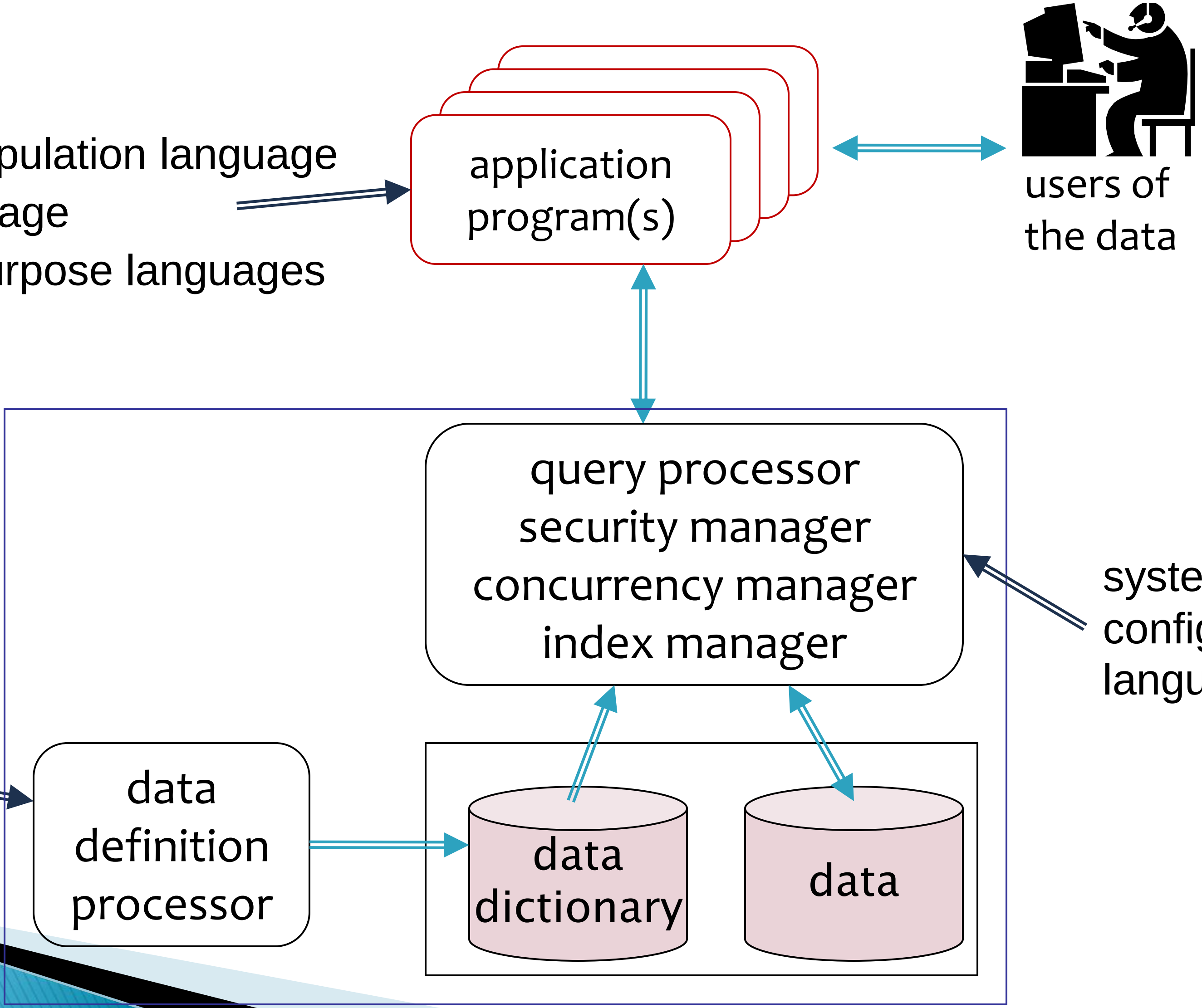
- DDL compiler generates a set of tables stored in a *data dictionary*
- Data dictionary contains metadata (i.e., data about data)
  - Database schema
  - Data *storage and definition* language
    - Specifies the storage structure and access methods used
  - Integrity constraints
    - Domain constraints
    - Referential integrity (e.g. *branch_name* must correspond to a valid branch in the *branch* table)
  - Authorization

DBMS Structure



DBMS Languages

DML: data manipulation language
QL: query language
GPL: general purpose languages



system configuration languages

DDL: data definition language

Database Users

Users are differentiated by the way they expect to interact with the system

- **Application programmers** – interact with system through DML calls
- **Sophisticated users** – form requests in a database query language
- **Specialized users** – write specialized database applications that do not fit into the traditional data processing framework
- **Naïve users** – invoke one of the permanent application programs that have been written previously
  - Examples, people accessing database over the web, bank tellers, clerical staff

Database Administrator

- Coordinates all the activities of the database system
  - has a good understanding of the enterprise’s information resources and needs.

- Database administrator's duties include:
  - Storage structure and access method definition
  - Schema and physical organization modification
  - Granting users authority to access the database
  - Backing up data
  - Monitoring performance and responding to changes
    - Database tuning

Database Architecture

The architecture of a database systems is greatly influenced by the underlying computer system on which the database is running:

- Centralized
- Client-server
- Parallel (multiple processors and disks)
- Distributed