Architecture of Database System

Layers

- External Level
- Conceptual Level
- Internal Level

Objective of 3 Layer Arch.

- Separate each user’s view of database from the way database is physically represented.
- Each user should be able to access the same data.
- DBA should be able to change the database storage structures without affecting the user’s view.

Architecture of DBMS

- External or View Level (user's view of database, each user is given different views according to user's requirement, e.g. date can be viewed)
- Conceptual or Logical Level (entities, relationships)
- Internal or Storage Level (physical representation)

Schema

- External Schema
- Conceptual Schema
- Internal Schema

Mapping

- Conceptual/External Mapping
- Conceptual/Internal Mapping

Data Independence

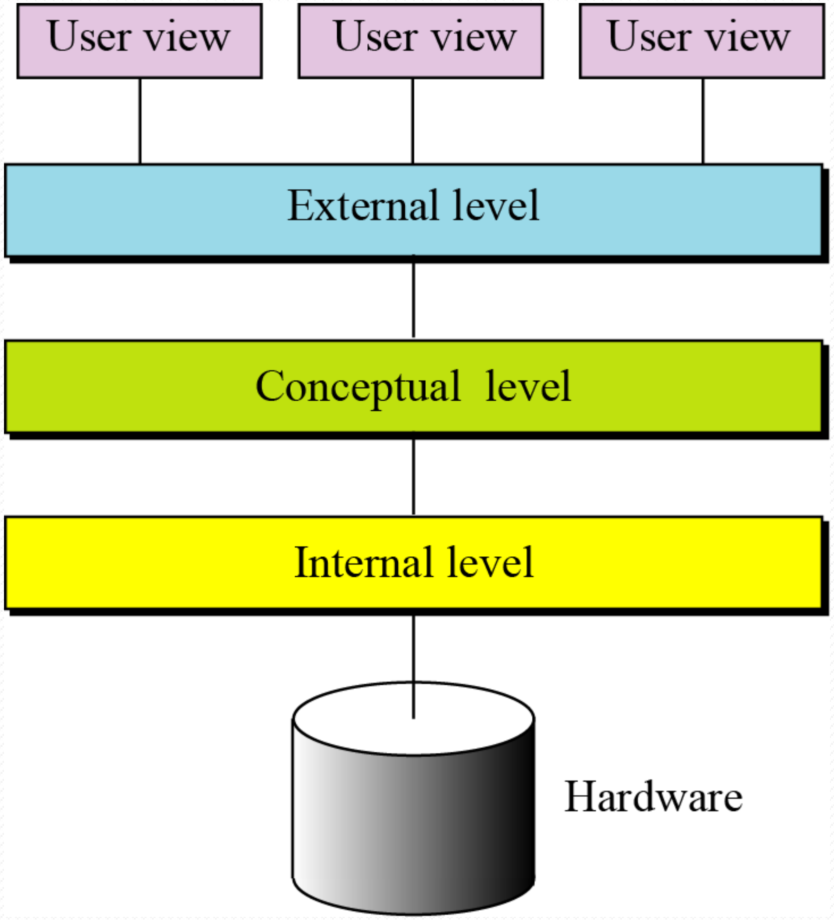
- Logical data Independence (conceptual schema can be changed without affecting the external schema)
- The change would be absorbed by mapping between external and conceptual levels.
- Physical data Independence (physical storage can be changed without affecting conceptual schema)
- The change would be absorbed by mapping between conceptual and internal levels.

Roles of DBA

- Making decisions concerning the content of DB
- Provides support to users
- Intreprets backup and recovery strategies
- Monitoring performance and responding to changes in requirements
- Define security and integrity checks
- Plans storage structures and access strategies

DATABASE ARCHITECTURE

The American National Standards Institute/Standards Planning and Requirements Committee (ANSI/SPARC) has established a three-level architecture for a DBMS: internal, conceptual and external .



Database architecture

Internal level

The internal level determines where data is actually stored on the storage devices. This level deals with low-level access methods and how bytes are transferred to and from storage devices. In other words, the internal level interacts directly with the hardware.

Conceptual level

The conceptual level defines the logical view of the data. The data model is defined on this level, and the main functions of the DBMS, such as queries, are also on this level. The DBMS changes the internal view of data to the external view that users need to see. The conceptual level is an intermediary and frees users from dealing with the internal level.

External level

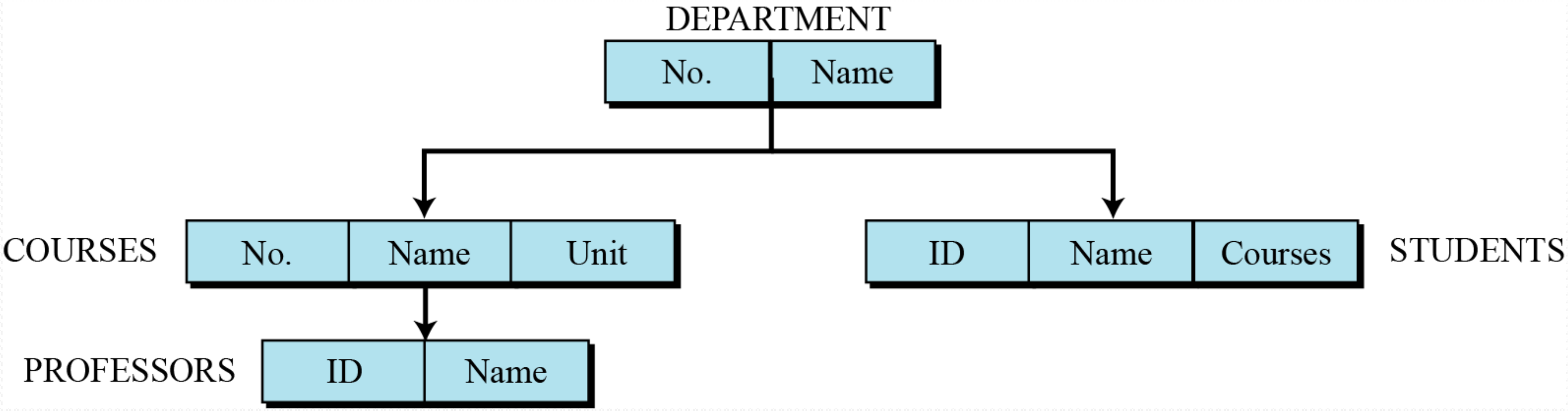
The external level interacts directly with the user (end users or application programs). It changes the data coming from the conceptual level to a format and view that is familiar to the users.

DATABASE MODELS

A database model defines the logical design of data. The model also describes the relationships between different parts of the data. In the history of database design, three models have been in use: the hierarchical model, the network model and the relational model.

Hierarchical database model

In the hierarchical model, data is organized as an inverted tree. Each entity has only one parent but can have several children. At the top of the hierarchy, there is one entity, which is called the root.



An example of the hierarchical model representing a university

Hierarchical Model

- In hierarchical data model, records are linked with other superior records on which they are dependent and also on the records, which are dependent on them.

- A tree structure may establish one-to-many relationship.

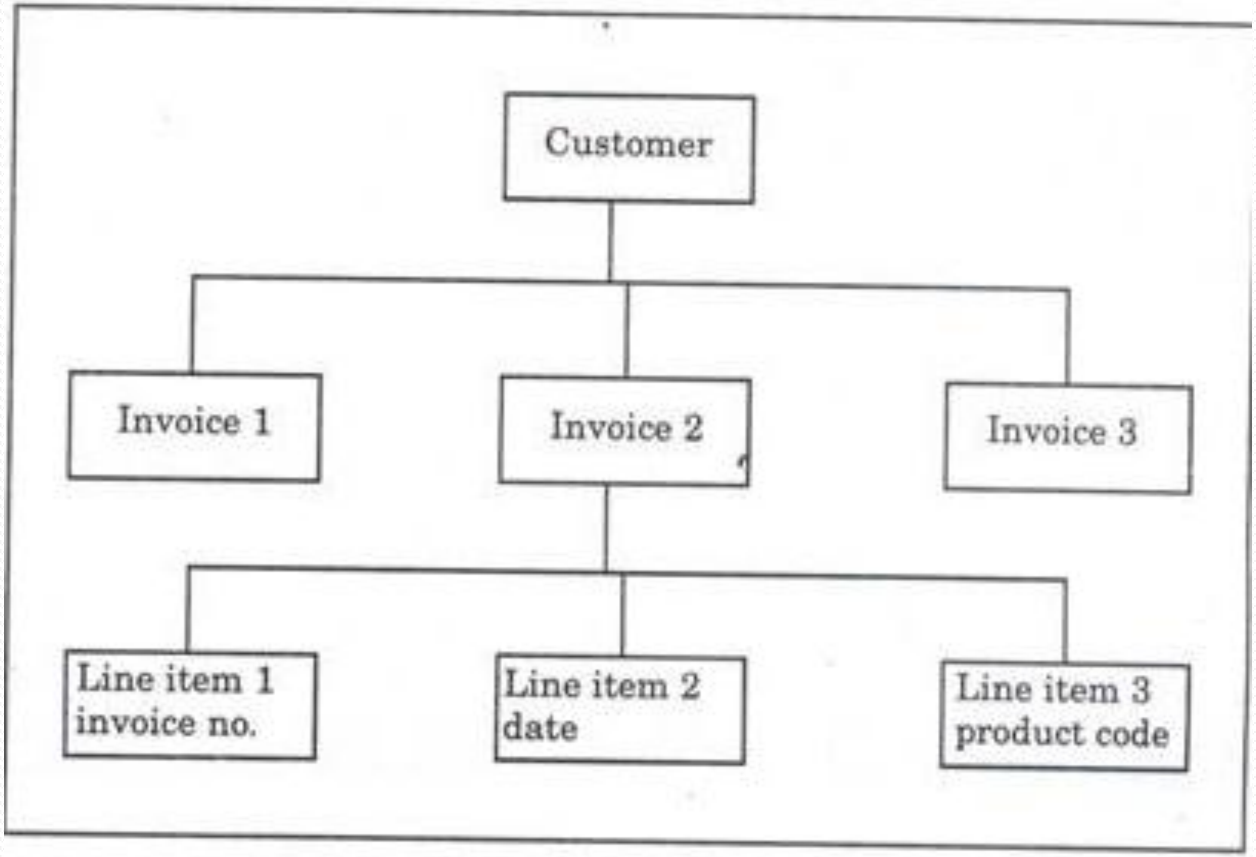
- E.g. structure of family

Example

- In a sales order processing system, a customer may have many invoices raised to him and each invoice may have dif-ferent data elements.

- Thus, the root level of data is customer, the second level is invoice and the last level is line items such as in-voice number, date, product, quantity, etc.

Example


Customer
Invoice 1
Invoice 2
Invoice 3
Line item 1
invoice no.
Line item 2
date
Line item 3
product code

Hierarchical Model

- Advantages:
- Simplicity (relationships between various layers is logically simple)
- Data Security
- Data Integrity (child segments are always automatically referred by its parent, so this model promotes data integrity)
- Efficiency(when DB contain large number of 1:N relationships and when users require large number of transactions, using data whose relationships are fixed)

Hierarchical Model

- Disadvantages:

- **Implementation Complexity**
- **Database Management Problems** (if you need to make any changes in database structure, you need to make necessary changes in all application programs that access the database)
- **Lack of structural independence** (If physical structure is changed, the applications will also have to be modified, as Hierarchical database system use physical storage paths to navigate to different data segments)

Hierarchical Model

- **Programs Complexity**
- Due to structural dependence and navigational structure, application programs and end users must know how data is distributed precisely in database in order to access data.
- **Implementation Limitation** (N:N relationships are very difficult to implement)

Network database model

In the network model, the entities are organized in a graph, in which some entities can be accessed through several paths.

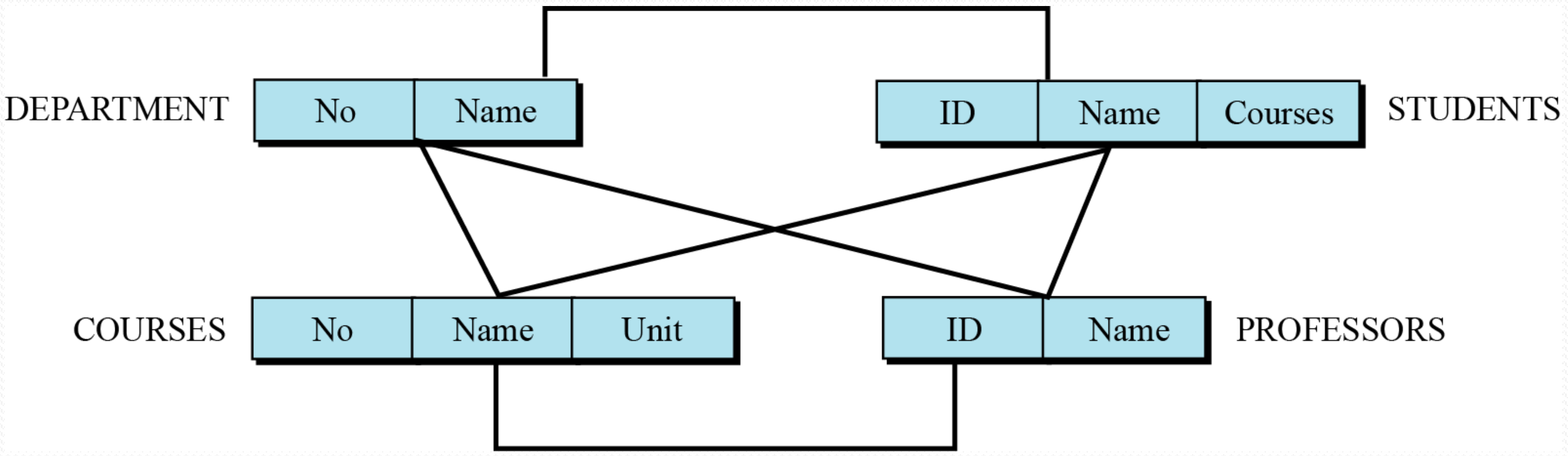


Figure 14.4 An example of the network model representing a university

Network Model

- Network model replaces the hierarchical tree with graph thus allowing more general connections among the nodes.

- The main difference of network model from hierarchical model is its ability to handle (N:N) relations.

- It allow a record to have more than one parent.

Network Model

- A network structure allows 1:1, 1:M, M:M relationships among entities.

- In network terminology, a relationship is a set.

- Each set is made up of at least two types of records : an owner record and a member record.

Network Model

- Advantages:

- Conceptual simplicity (easy to design)
- Capability to handle more relationship types
- Ease of data access
- Data Integrity
- Data Independence
- Database Standards (it was drawback in hierarchical model, network model is based on standards ANSI/SPARC)

Network Model

- Disadvantages :
- **System complexity** (all records are maintained using pointers)
- **Operational anomalies** (network model's insertion, deletion and updating operations require large number of pointer adjustments)
- **Absence of structural independence** (same issue in hierarchical model)

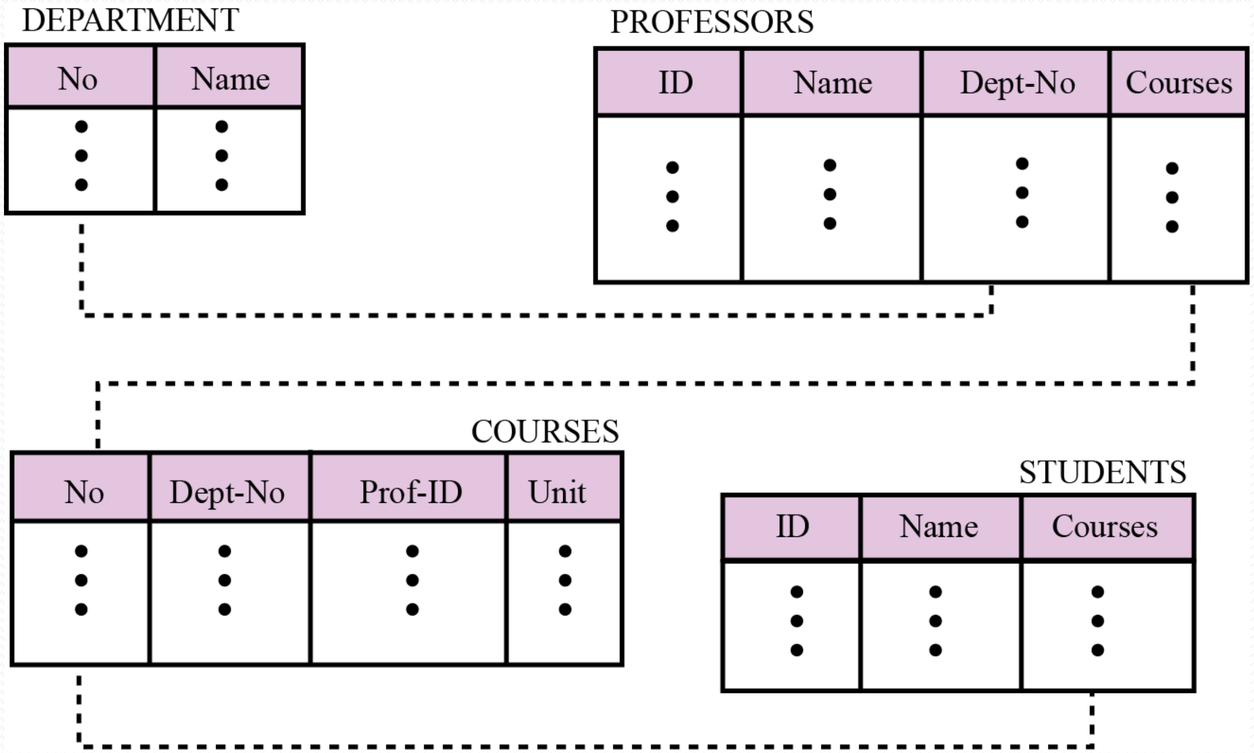
Network Model

- As there is no definite path defined for retrieval of data, the number of links is very large and thus network databases are complex, slow and difficult to implement.

- In view of the difficulty in implementation, network model is used only when all other options are closed.

Relational database model

In the relational model, data is organized in two-dimensional tables called relations. The tables or relations are, however, related to each other, as we will see shortly.



DEPARTMENT

No	Name
⋮	⋮

PROFESSORS

ID	Name	Dept-No	Courses
⋮	⋮	⋮	⋮

COURSES

No	Dept-No	Prof-ID	Unit
⋮	⋮	⋮	⋮

STUDENTS

ID	Name	Courses
⋮	⋮	⋮

An example of the relational model representing a university

Relational Model

- Relational model stores data in the form of tables.

- Consists of three major components :

1. Set of relations that define the way data can be represented
2. Integrity rules that define the procedure to protect the data
3. The operations that can be performed on data

Relational Model Characteristics

- The whole data is conceptually represented as an orderly arrangement of data into rows and columns, called a relation or table

- At any given row/column position in relation there is one and only one value.

Relational Model Characteristics

- The data dictionary has information regarding the database structure including the data type; size, etc., definitions, relation-ships and access permissions.

- The authorized users can learn about the database environment and change the environment using the data description language (DDL).

Relational Model Characteristics

- A data manipulation language (DML) is available to users includ-ing programmers for creation, insertion, modification, retrieval, organizing and deletions of any part of the database.

- Any modification in the structure of database in terms of split-ting the table horizontally or vertically should not have any impact on the logic of the program using the database.

Relational Model

- Terminology :

- **Tuple** (each row of data)
- **Attribute** (each column in the tuple)
- **Cardinality** (number of tuples in relation)
- **Degree of a relation** (number of attributes in relation determine its degree)

Relational Model

- Terminology :

- **Domains**
- Specifies the kind of data represented by the attribute. More particularly, a domain is set of all possible values that an attribute may contain

Relational Model

- Advantages

- Structural Independence
- Conceptual Simplicity
- Design, implementation, maintenance and usage ease
- The presence of powerful and easy to use query capability

Relational Model

- Disadvantages

- Hardware overheads (Relational database system hides the implementation complexities and physical storage from users, for doing this RDBMS need powerful computers)

- Ease of design can lead to bad design (The users are not aware of complex details of physical data storage, this ease of design can led to development of very poorly designed database management systems)