INTRODUCTION

Introduction to Database Systems

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IN THIS LECTURE

- Course Information
- Some History and challenges
- Relational DB

- For more information
  - Connolly and Begg – Chapters 1 and 2
  - Ullman and Widom (2ed.) – Chapter 1
  - Designing Data-Intensive Applications - Chapter 2

COURSE INFORMATION

- Score Items
  - Two exams(10,12)
  - Five sets of exercises(10,8+1)
  - Class activity(+1)
- Attendance is not mandatory

COURSE INFORMATION

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TEXTBOOK

- Recommended textbooks:
  - 'Database Systems: A practical approach to design, implementation and management' by Connolly and Begg
  - `A first course in database systems' by Ullman and Widom.
- Other textbooks:
  - There are lots of database texts
  - Most of them would be fine also
- Advanced topics: Designing Data-Intensive Applications

COURSE OVERVIEW

- Several main topics
  - Database systems
  - Data models
  - Database design
  - SQL
  - RAID
  - Transactions
  - concurrency
  - NoSQL Databases
- Practical sessions
  - SQL
    - creating a database
    - querying a database
  - NoSQL

WHY STUDY DATABASES?

- Databases are useful
  - Many computing applications deal with large amounts of information
  - Database systems give a set of tools for storing, searching and managing this information
- Databases in CS
  - Databases are a ‘core topic’ in computer science
  - Basic concepts and skills with database systems are part of the skill set you will be assumed to have as a CS graduate

WHAT IS A DATABASE?

- "A set of information held in a computer"

  Oxford English Dictionary

- "One or more large structured sets of persistent data, usually associated with software to update and query the data"

  Free On-Line Dictionary of Computing

- "A collection of data arranged for ease and speed of search and retrieval"

  Dictionary.com

DATABASES

- Web indexes
- Library catalogues
- Medical records
- Bank accounts
- Stock control
- Personnel systems
- Product catalogues
- Telephone directories
- Train timetables
- Airline bookings
- Credit card details
- Student records
- Customer histories
- Stock market prices
- Discussion boards
- and so on…

PREVIOUS ATTEMPTS

- File based DBs
- Document Database(Hierarchy)
  - IMS: Information Management System, IBM first released commercially in 1968, Originally developed for stock-keeping in the Apollo space program in 1960
- Network models
  - CODASYL: Conference on Data Systems Languages

PREVIOUS ATTEMPTS

```
<?xml version="1.0" encoding="UTF-8"?>
- <EmployeeData>
  - <employee id="34594">
        <firstName>Heather</firstName>
        <lastName>Banks</lastName>
        <hireDate>1/19/1998</hireDate>
        <deptCode>BB001</deptCode>
        <salary>72000</salary>
    </employee>
  - <employee id="34593">
        <firstName>Tina</firstName>
        <lastName>Young</lastName>
        <hireDate>4/1/2010</hireDate>
        <deptCode>BB001</deptCode>
        <salary>65000</salary>
    </employee>
</EmployeeData>
```

FILE BASED SYSTEMS

- File based systems
  - Data is stored in **files**
  - Each file has a **specific format**
  - Programs that use these files depend on **knowledge** about that format
- Problems:
  - No standards
  - Data duplication
  - Data dependence
  - No way to generate ad hoc queries
  - No provision for security, recovery, concurrency, etc.

EARLY DATABASES

- ANSI - American National Standards Institute
- SPARC - Standards Planning and Requirements Committee
  - 1975 - Proposed a framework for DBs
  - A **three-level** architecture
    - **Internal level:** For systems designers
    - **Conceptual level:** For database designers and administrators
    - **External level:** For database users

ANSI/SPARC ARCHITECTURE

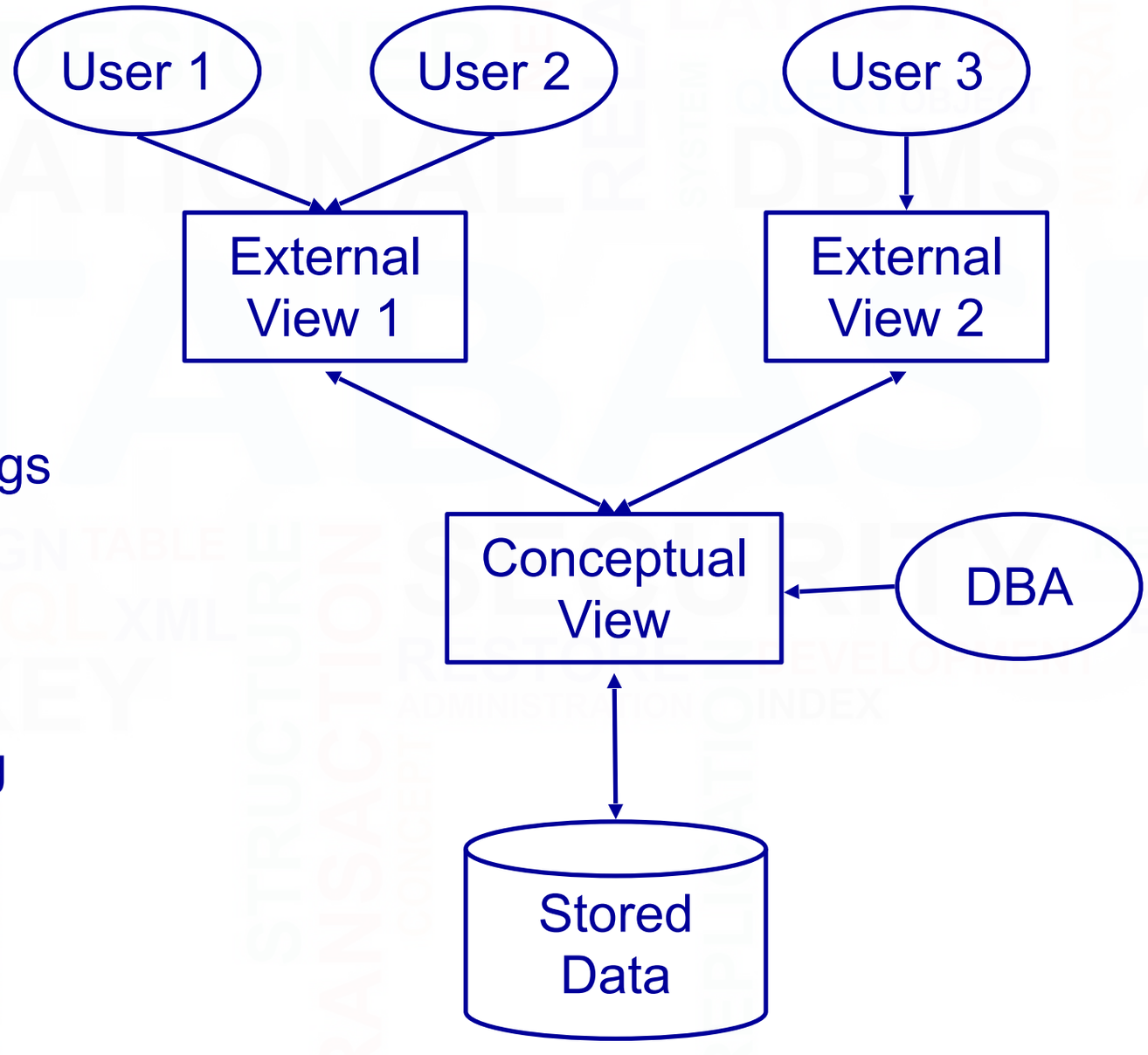
External Schemas

External/Conceptual Mappings

Conceptual Schema

Conceptual/Internal Mapping

Internal Schema



DATABASE USERS

- **End users**
  - Use the database system to achieve some goal
- **Application developers**
  - Write software to allow end users to interface with the database system
- **Database Administrator (DBA)**
  - Designs & manages the database system
- **Database systems programmer**
  - Writes the database software itself

DATABASE SYSTEMS

- A database system consists of
  - Data (the database)
  - Software
  - Hardware
  - Users
- We focus mainly on the software

- Database systems allow users to
  - Store
  - Update
  - Retrieve
  - Organize
  - Protect
- their data.

DATABASE MANAGEMENT SYSTEMS

- A database is a collection of information

- A database management system (DBMS) is the software that controls information

- Examples:
  - Oracle
  - DB2 (IBM)
  - MS SQL Server
  - MS Access
  - Ingres
  - PostgreSQL
  - MySQL

WHAT THE DBMS DOES

- Provides users with
  - Data definition language (**DDL**)
  - Data manipulation language (**DML**)
  - Data control language (**DCL**)
- Often these are all the same language

- DBMS provides
  - Persistence
  - Concurrency
  - Integrity
  - Security
  - Data independence
- Data Dictionary
  - Describes the database itself

DATA DICTIONARY - METADATA

- The dictionary or catalog stores information about the database itself
- This is **data about data** or ‘metadata’
- Almost **every aspect** of the DBMS uses the dictionary
- The dictionary holds
  - **Descriptions** of database objects (tables, users, rules, views, indexes,…)
  - **Information** about who is using which data (locks)
  - **Schemas** and **mappings**

INTERNAL LEVEL

- Deals with physical storage of data
  - **Structure** of records on disk - files, pages, blocks
  - **Indexes** and **ordering** of records
- Used by database system **programmers**

- Internal Schema

```
RECORD EMP                LENGTH=44
HEADER: BYTE(5)           OFFSET=0
NAME: BYTE(25)            OFFSET=5
SALARY: FULLWORD          OFFSET=30
DEPT: BYTE(10)            OFFSET=34
```

CONCEPTUAL LEVEL

- Deals with the organization of the data as a whole
  - **Abstractions** are used to remove unnecessary details of the internal level
- Used by **DBAs** and application programmers

- Conceptual Schema

```
CREATE TABLE
Employee (
 Name        VARCHAR(25),
 Salary      REAL,
 Dept_Name   VARCHAR(10)
)
```

EXTERNAL LEVEL

- Provides a view of the database tailored to a user
  - Parts of the data may be **hidden**
  - Data is presented in a **useful** form
- Used by **end users** and application programmers

- External Schemas

```
Payroll:
  String Name
  double Salary

Personnel:
  char *Name
  char *Department
```

MAPPINGS

- Mappings **translate** information from one level to the next
  - External/Conceptual
  - Conceptual/Internal
- These mappings provide data **independence**
- Physical data independence
  - Changes to internal level shouldn't affect conceptual level
- Logical data independence
  - Conceptual level changes shouldn't affect external levels

RELATIONAL SYSTEMS

- Problems with early databases
  - **Navigating** the records requires complex programs
  - There is **minimal data independence**
  - **No theoretical** foundations
- Then, in 1970, E. F. Codd wrote “A Relational Model of Data for Large Shared Databanks” and introduced the relational model

RELATIONAL SYSTEMS

- Information is stored as ***tuples*** or **records** in **relations** or **tables**
- There is a **sound** **mathematical theory** of relations
- Most modern DBMS are based on the relational model
- The relational model covers 3 areas:
  - **Data structure**
  - **Data integrity**
  - **Data manipulation**
- More details in the next lecture…

END

Thanks to Mohammad Tanhaei, Assistant Prof. At Ilam University

NEXT LECTURE

The Relational Model

- Relational data structure
- Relational data integrity
- Relational data manipulation

For more information

- Connolly and Begg chapters 3 and 4
- Ullman and Widom (2 ed.) Chapter 3.1, 5.1
- E.F. Codd's paper