

Introduction to Database Systems

Database Systems Lecture 5

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
- For example:
 - 'Database Systems' by CJ Date

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...

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
 - Organise
 - Protect their data.

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 Management Systems

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

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.

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...

ANSI/SPARC Architecture

- 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

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 organisation 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) )
```

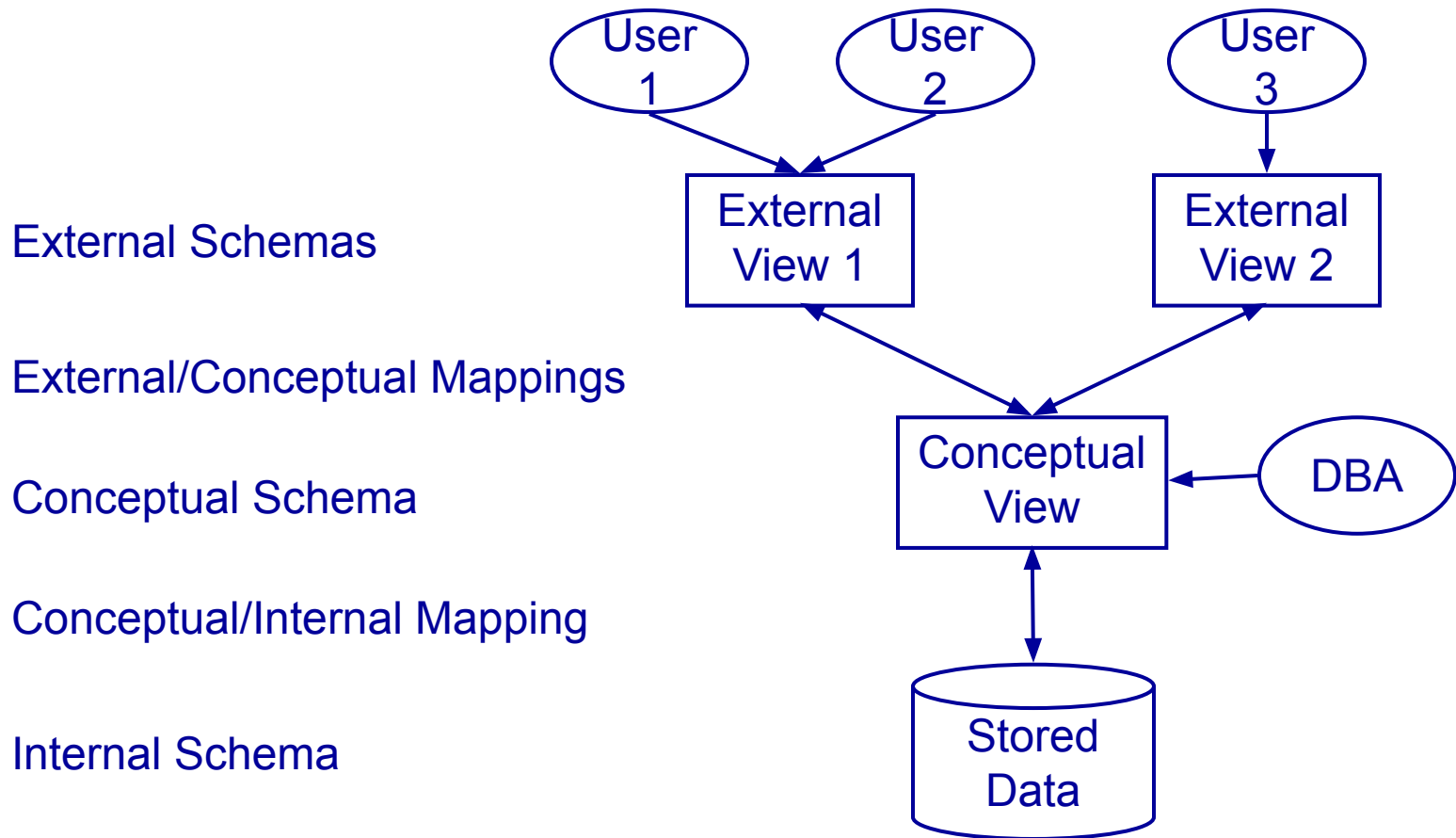

External Level

- 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

ANSI/SPARC Architecture



This Lecture in Exams

- Describe the three levels of the ANSI/SPARC model. You should include information about what each level is for, which users might be interested in which levels, and how the levels relate to one another. (2004/05, 7 marks)

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

(there is a link on last year's G51DBS
webpage)