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# DATABASE MANAGEMENT SYSTEM BCSC0003

Dr. Neeraj Gupta
Assistant Professor, Dept. of CEA
neeraj.gupta@gla.ac.in

# OUTLINE

- ❑DBMS
- ❑DBMS Applications
- ❑File system vs Database system
- ❑Data Abstraction
- ❑Data Models and Their Categories
- ❑Schemas, Instances, and States
- ❑Three-Schema Architecture

# 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

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# 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

# 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

# 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

# DRAWBACKS OF USING FILE SYSTEMS TO STORE DATA

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 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

**Database systems offer solutions to all the above problems**

# DATA ABSTRACTION

Real Life Example of Abstraction

# DATA MODELS

**Data Model:**

- A set of concepts to describe the ***structure*** of a database, the ***operations*** for manipulating these structures, and certain ***constraints*** that the database should obey.

**Data Model Structure and Constraints:**

- Constructs are used to define the database structure
- Constructs typically include ***elements*** (and their ***data types***) as well as groups of elements (e.g. ***entity, record, table***), and ***relationships*** among such groups
- Constraints specify some restrictions on valid data; these constraints must be enforced at all times

# DATA MODELS

**Data Model Operations:**

- These operations are used for specifying database *retrievals* and *updates* by referring to the constructs of the data model.

- Operations on the data model may include
  - ***basic model operations*** (e.g. generic insert, delete, update) and
  - ***user-defined operations*** (e.g. compute_student_gpa, update_inventory)

# CATEGORIES OF DATA MODELS

**Conceptual (high-level, semantic) data models:**

- Provide concepts that are close to the way many users perceive data.
  - (Also called ***entity-based*** or ***object-based*** data models.)

**Physical (low-level, internal) data models:**

- Provide concepts that describe details of how data is stored in the computer. These are usually specified in an ad-hoc manner through DBMS design and administration manuals

**Implementation (representational) data models:**

- Provide concepts that fall between the above two, used by many commercial DBMS implementations (e.g. relational data models used in many commercial systems).

# SCHEMAS VERSUS INSTANCES

Database Schema:

- The ***description*** of a database.
- Includes descriptions of the database structure, data types, and the constraints on the database.

Schema Diagram:

- An ***illustrative*** display of (most aspects of) a database schema.

Schema Construct:

- A ***component*** of the schema or an object within the schema, e.g., STUDENT, COURSE.

# SCHEMAS VERSUS INSTANCES

Database State:

- The actual data stored in a database at a ***particular moment in time***. This includes the collection of all the data in the database.

- Also called database instance (or occurrence or snapshot).
  - The term *instance* is also applied to individual database components, e.g. *record instance, table instance, entity instance*

# DATABASE SCHEMA VS. DATABASE STATE

Database State:

- Refers to the ***content*** of a database at a moment in time.

Initial Database State:

- Refers to the database state when it is initially loaded into the system.

Valid State:

- A state that satisfies the structure and constraints of the database.

# DATABASE SCHEMA VS. DATABASE STATE

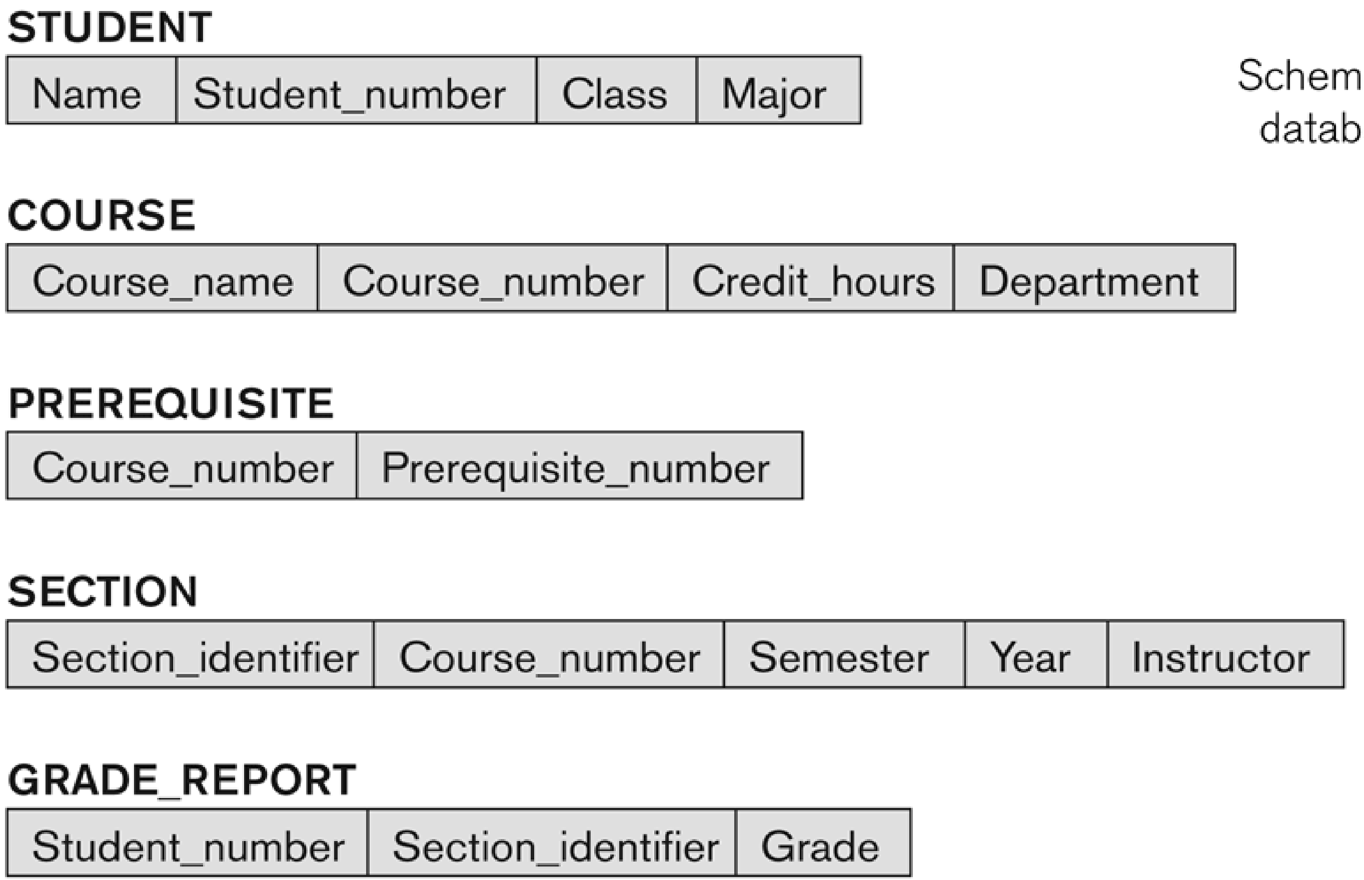
Distinction

- The ***database schema*** changes very infrequently.
- The ***database state*** changes every time the database is updated.

**Schema** is also called **intension.**

**State** is also called **extension.**

# EXAMPLE OF A DATABASE SCHEMA



**STUDENT**

| Name | Student_number | Class | Major |
|---|---|---|---|

**COURSE**

| Course_name | Course_number | Credit_hours | Department |
|---|---|---|---|

**PREREQUISITE**

| Course_number | Prerequisite_number |
|---|---|

**SECTION**

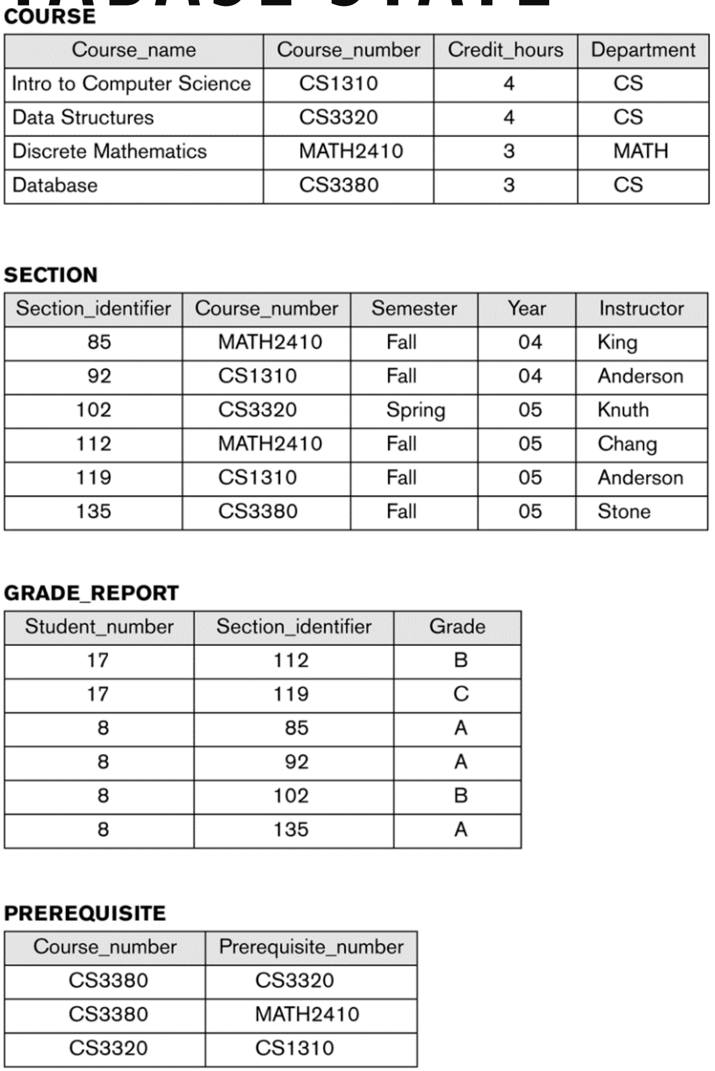
| Section_identifier | Course_number | Semester | Year | Instructor |
|---|---|---|---|---|

**GRADE_REPORT**

| Student_number | Section_identifier | Grade |
|---|---|---|

**Figure 2.1**
Schema diagram for the database in Figure 1.2.

# EXAMPLE OF A DATABASE STATE



**COURSE**

| Course_name | Course_number | Credit_hours | Department |
|---|---|---|---|
| Intro to Computer Science | CS1310 | 4 | CS |
| Data Structures | CS3320 | 4 | CS |
| Discrete Mathematics | MATH2410 | 3 | MATH |
| Database | CS3380 | 3 | CS |

**SECTION**

| Section_identifier | Course_number | Semester | Year | Instructor |
|---|---|---|---|---|
| 85 | MATH2410 | Fall | 04 | King |
| 92 | CS1310 | Fall | 04 | Anderson |
| 102 | CS3320 | Spring | 05 | Knuth |
| 112 | MATH2410 | Fall | 05 | Chang |
| 119 | CS1310 | Fall | 05 | Anderson |
| 135 | CS3380 | Fall | 05 | Stone |

**GRADE_REPORT**

| Student_number | Section_identifier | Grade |
|---|---|---|
| 17 | 112 | B |
| 17 | 119 | C |
| 8 | 85 | A |
| 8 | 92 | A |
| 8 | 102 | B |
| 8 | 135 | A |

**PREREQUISITE**

| Course_number | Prerequisite_number |
|---|---|
| CS3380 | CS3320 |
| CS3380 | MATH2410 |
| CS3320 | CS1310 |

**Figure 1.2**
A database that stores student and course information.

# THREE-SCHEMA ARCHITECTURE

Proposed to support DBMS characteristics of:

- **Program-data independence.**
- Support of **multiple views** of the data.

Not explicitly used in commercial DBMS products, but has been useful in explaining database system organization

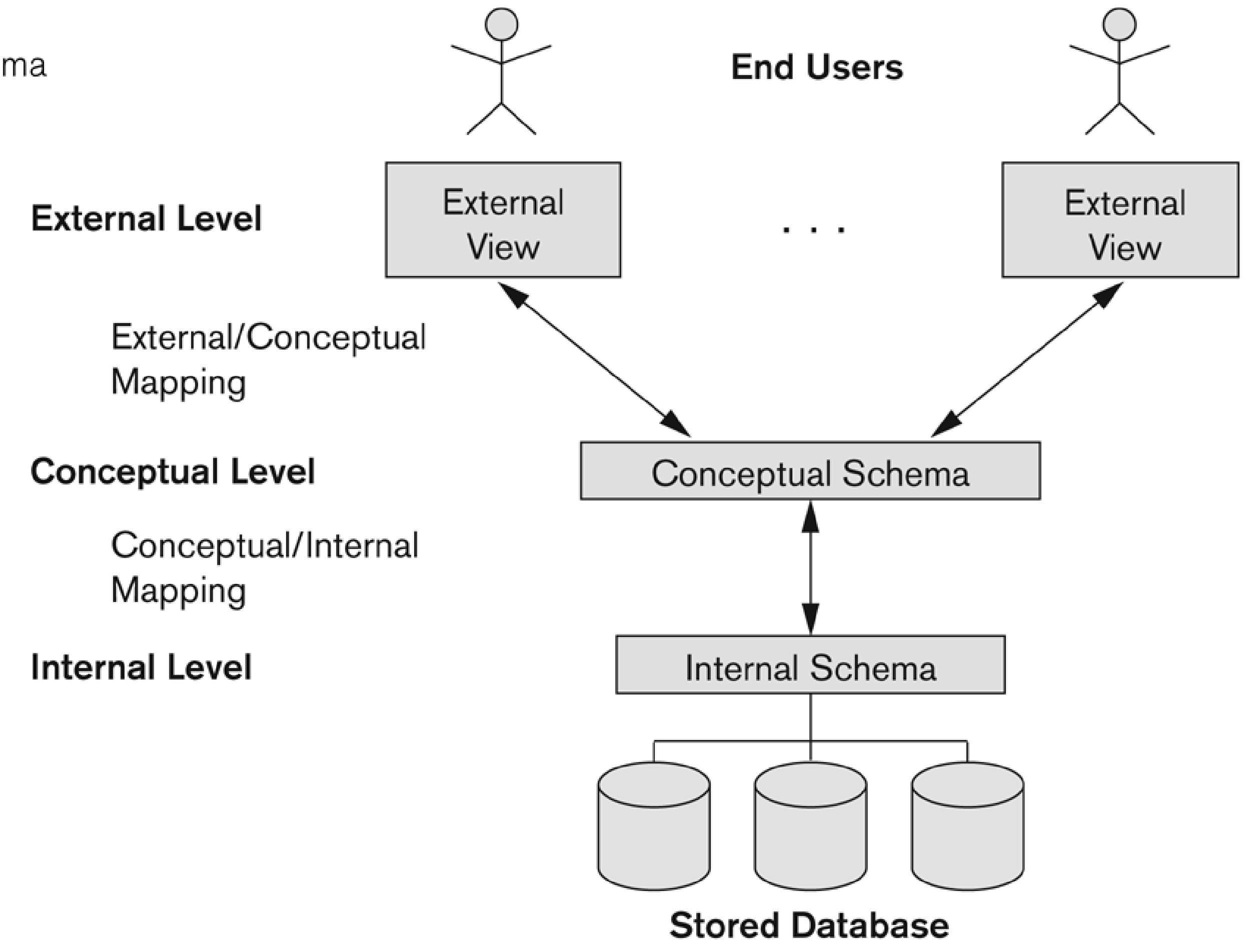
# THREE-SCHEMA ARCHITECTURE

Defines DBMS schemas at ***three*** levels:

- **Internal schema** at the internal level to describe physical storage structures and access paths (e.g indexes).
  - Typically uses a **physical** data model.
- **Conceptual schema** at the conceptual level to describe the structure and constraints for the whole database for a community of users.
  - Uses a **conceptual** or an **implementation** data model.
- **External schemas** at the external level to describe the various user views.
  - Usually uses the same data model as the conceptual schema.

# THE THREE-SCHEMA ARCHITECTURE

**Figure 2.2**
The three-schema architecture.

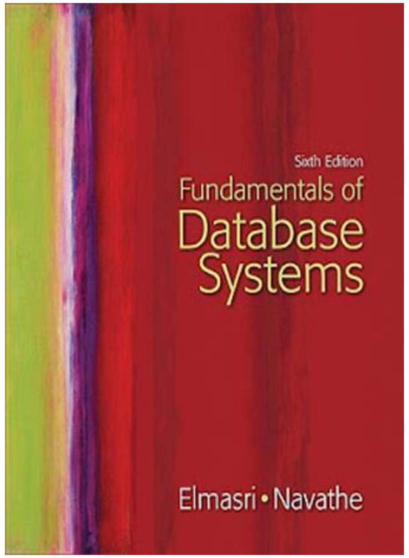


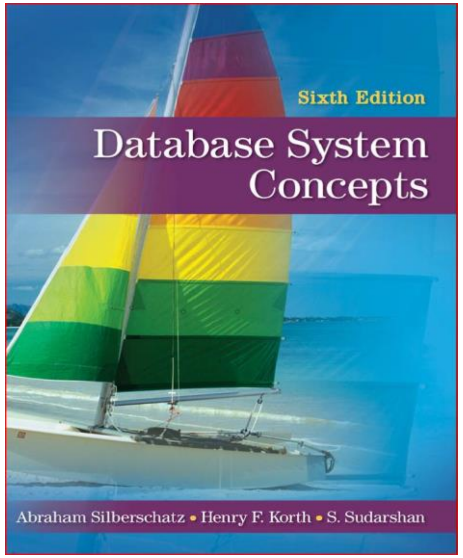
# THREE-SCHEMA ARCHITECTURE

Mappings among schema levels are needed to transform requests and data.

- Programs refer to an external schema, and are mapped by the DBMS to the internal schema for execution.
- Data extracted from the internal DBMS level is reformatted to match the user's external view (e.g. formatting the results of an SQL query for display in a Web page)

# REFERENCE BOOKS





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