IT-212
Database Systems
Lecture-02

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Last Lecture Summary

- Some common uses of database systems
- Characteristics of file-based systems
- Problems with file-based approach
- The Database (DB)
- Database Management System (DBMS)
- Typical functions of a DBMS
- Major components of the DBMS environment
- Personnel involved in the DBMS environment
- Advantages and disadvantages of DBMSs
- History of the development of DBMSs

Today's Topics

- Data Models and Their Categories
- History of Data Models
- Schemas, Instances, and States
- Structure of Relational Databases
- Database Schema
- ANSI-SPARC Three-Level Architecture
- Schemas (Three-Level Architecture)
- Mappings
- Data Independence

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;
  - Constraints must be enforced at all times

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.
- **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 and 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 (entity) within the schema, e.g., STUDENT, COURSE.
- **Instance:** The collection of data and information that the database stores at any particular moment.
  - The term *instance* is also applied to individual database components, e.g. *record instance, table instance, entity instance*

Example of a Database Schema

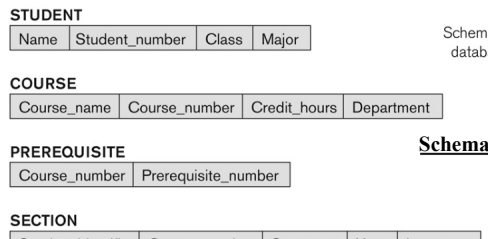


Figure 2.1
Schema diagram for the database in Figure 1.2.

Book: *Ramez Elmasri and Shamkant B. Navathe*

Schema: instructor (ID, name, dept_name, salary)

Instance

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
10101	Srinivasan	Comp. Sci.	65000
58583	Califieri	History	62000
83821	Brandt	Comp. Sci.	92000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

Book: *Silberschatz, Korth and Suda*

Database State, Distinction, Intension, Extension

- 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.
- 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.
- 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 state

Instructor Relation

attributes (or columns)

ID	name	dept_name	salary
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

tuples (or rows)

Book: *Silberschatz, Korth and Suda*

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

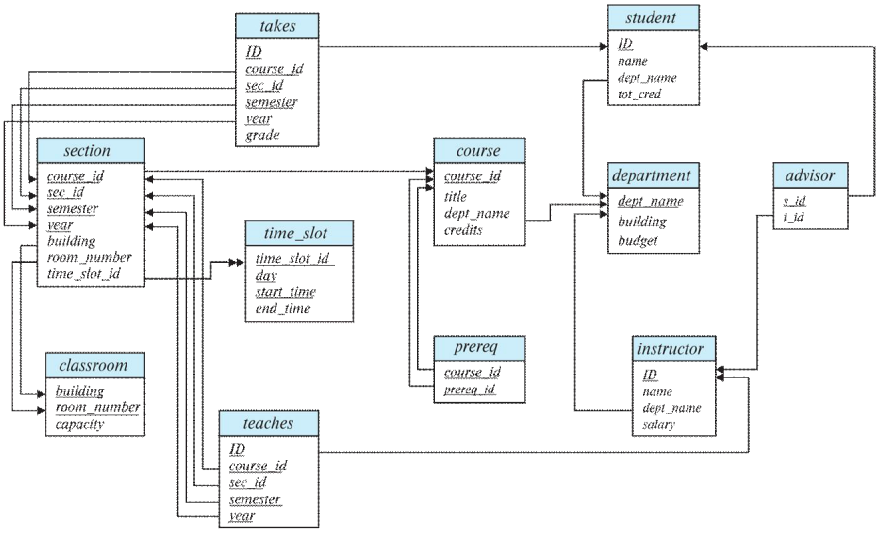
PREREQUISITE

Course_number	Prerequisite_number
CS3380	CS3320
CS3380	MATH2410
CS3320	CS1310

Figure 1.2
A database that stores student and course information.

Book: *Ramez Elmasri and Shamkant B. Navathe*

Schema Diagram for University Database



Book: *Silberschatz, Korth and Suda*

Three-Level / Schema Architecture

Objectives:

– All users should be able to access same data but have a different customized view.

– A user's view is protected from changes made in other views– Users should not need to know physical database storage details.

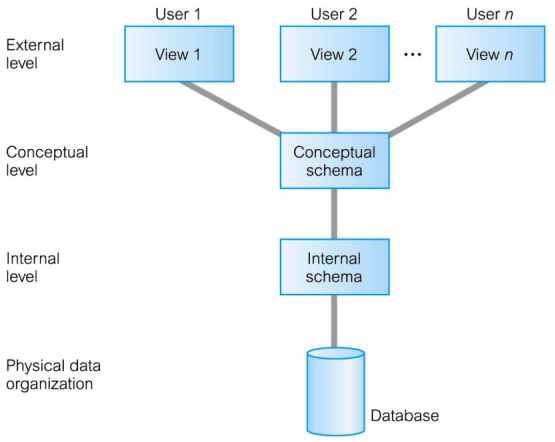
– DBA should be able to change database storage structures without affecting the users' views

– Internal structure of database should be unaffected by changes to physical aspects of storage

– DBA should be able to change conceptual structure of database without affecting all users

ANSI-SPARC Three-Level Architecture (1)

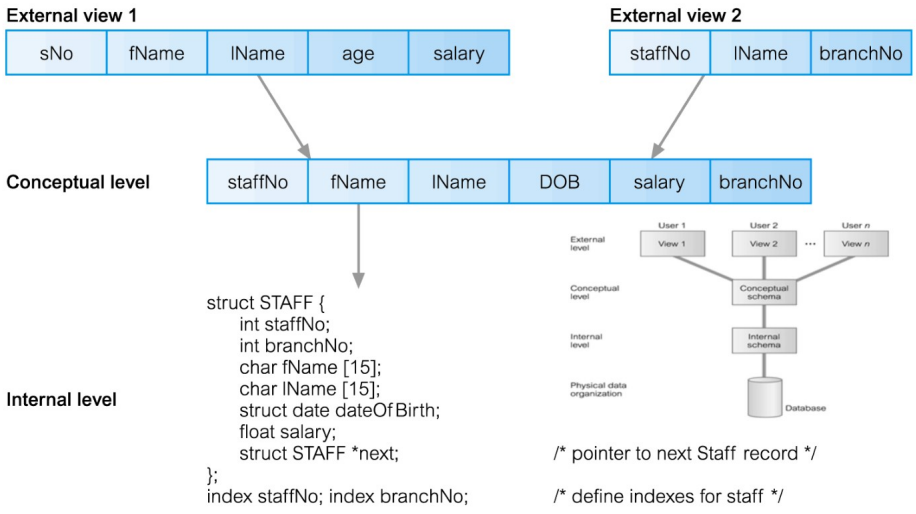
- **ANSI-SPARC**: **A**merican **N**ational **S**tandards **I**nstitute, **S**tandards **P**lanning **A**nd **R**equirements **C**ommittee
  – An abstract design standard for a DBMS, first proposed in 1975.



ANSI-SPARC Three-Level Architecture (2)

- **External Level**
  - Users' view of the database
  - Describes that part of database that is relevant to a particular user
  - Different views may have different representation of same data (e.g. different date formats, age derived from DOB etc.)
- **Conceptual Level**
  - Describes **what** data is stored in database and relationships among the data
  - Along with any constraints on data
  - Independent of any storage considerations
- **Internal Level**
  - Physical representation of the database on the computer
  - Describes **how** the data is stored in the database
  - physical implementation of the database to achieve optimal runtime performance and storage space utilization
  - Data structures and file organizations used to store data on storage devices
  - Interfaces with the operating system access methods to place the data on the storage devices, build the indexes, retrieve the data, and so on

ANSI-SPARC Three-Level Architecture (3)



Schemas (Three-Level Architecture)

- External Schemas
  - Also called subschemas
  - Multiple schemas per database
  - Corresponds to different views of data
- Conceptual Schema
  - Describes all the entities, attributes, and relationships together with integrity constraints
  - Only one schema per database
- Internal Schema
  - A complete description of the internal model, containing the definitions of stored records, the methods of representation, the data fields, and the indexes and storage structures used
  - Only one schema per database

Mappings (1)

- The DBMS is responsible for mapping between these three types of schema:
  - The DBMS must check that each external schema is derivable from the conceptual schema, and it must use the information in the conceptual schema to map between each external schema and the internal schema
- Types of mappings
  - Conceptual / Internal mapping
  - External / Conceptual mapping

Mapping (2)

Conceptual / Internal Mapping

- Enables the DBMS to
  - Find the actual record or combination of records in physical storage that constitute a logical record in the conceptual schema,
  - Together with any constraints to be enforced on the operations for that logical record
  - It also allows any differences in entity names, attribute names, attribute order, data types, and so on, to be resolved

External / Conceptual Mapping

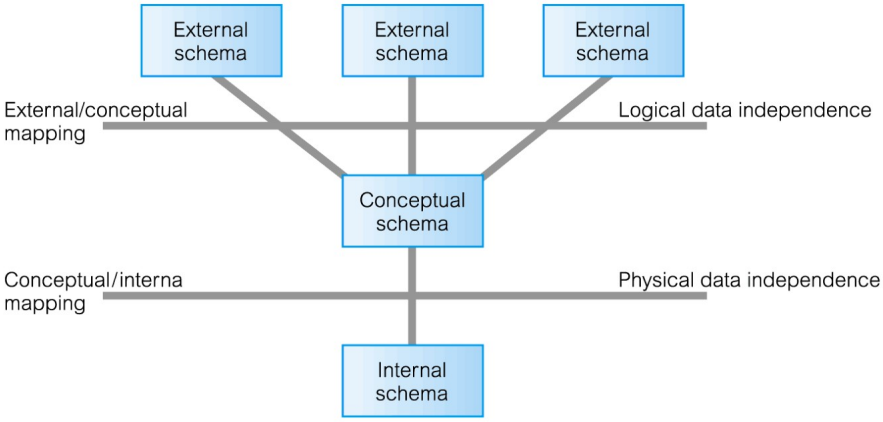
- Enables the DBMS to
  - Map names in the user's view on to the relevant part of the conceptual schema

Data Independence

- Logical Data Independence
  - Refers to immunity (freedom) of external schemas to changes in conceptual schema
  - Conceptual schema changes (e.g. addition/removal of entities)
  - Should not require changes to external schema or rewrites of application programs

- Physical Data Independence
  - Refers to immunity of conceptual schema to changes in the internal schema – Internal schema changes (e.g. using different file organizations, storage structures, storage devices etc.)
  - Should not require change to conceptual or external schemas

Data Independence and the ANSI-SPARC Three-Level Architecture



Summary

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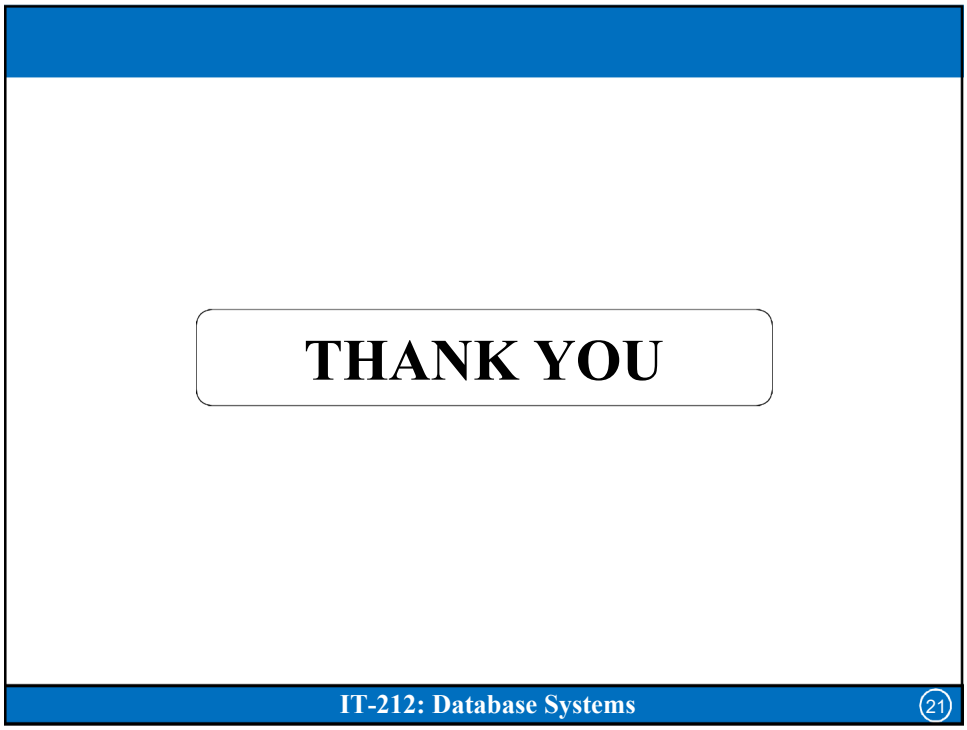
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