Database System Concepts & Architecture
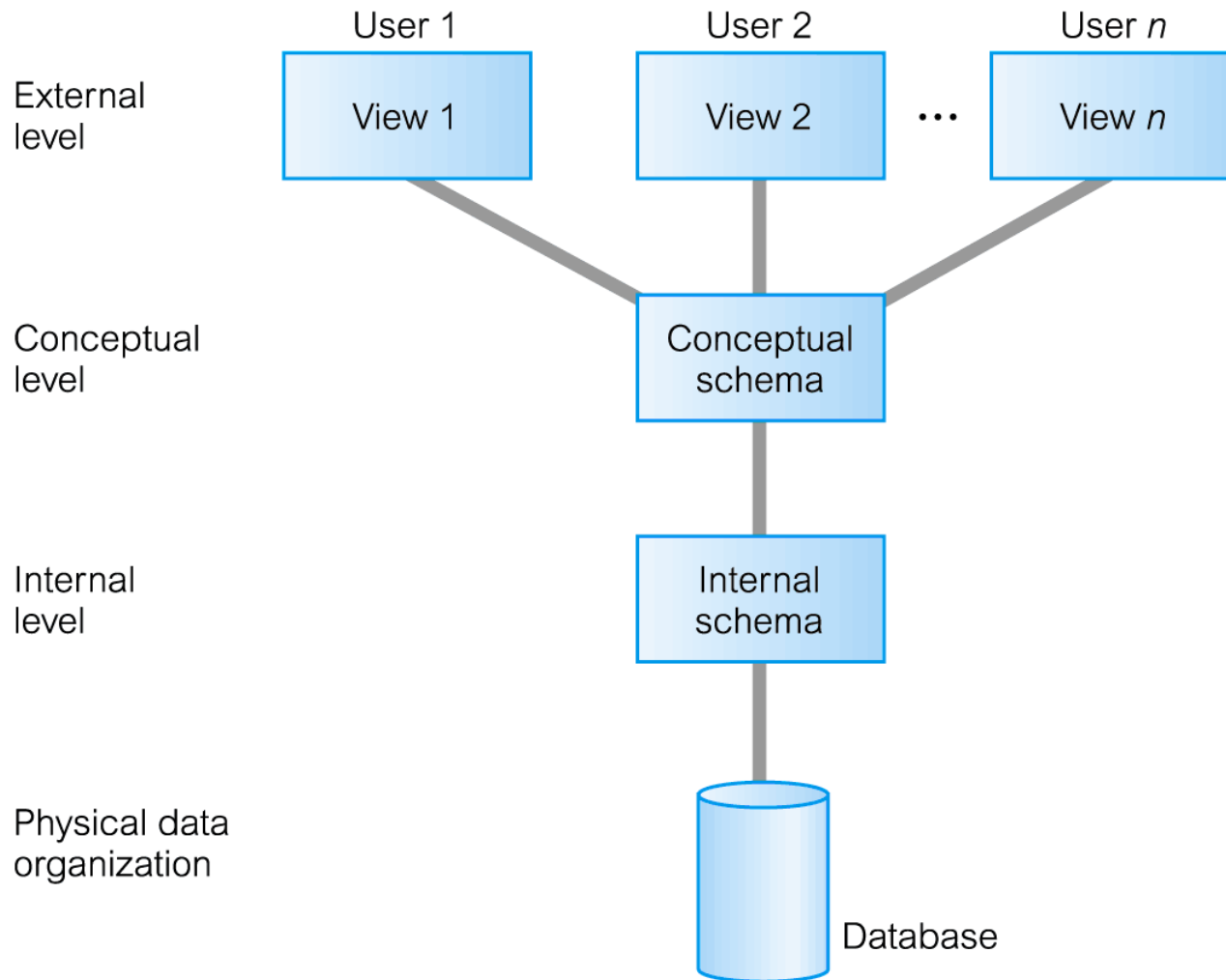
Wen-Chih Peng

Covid-19

- Something about Covid 2019
  - [鍵盤救國](https://www.businessweekly.com.tw/focus/blog/3001698)
    https://www.businessweekly.com.tw/focus/blog/3001698
  - 口罩地圖
    https://mask.pdis.nat.gov.tw
  - 類流感分析
    https://fluforecast.cdc.gov.tw
  - **Novel Corona Virus 2019 Dataset**

ANSI-SPARC Three-Level Architecture

Examples of Three Levels of ANSI-SPARC Architecture

External view 1

sNo	fName	lName	age	salary

External view 2

| staffNo	lName	branchNo

Conceptual level

staffNo	fName	lName	DOB	salary	branchNo

Internal level

```
struct STAFF {
    int staffNo;
    int branchNo;
    char fName [15];
    char lName [15];
    struct date dateOfBirth;
    float salary;
    struct STAFF *next;              /* pointer to next Staff record */
};
index staffNo; index branchNo;      /* define indexes for staff */
```

# Data Independence and the ANSI-SPARC Three-Level Architecture
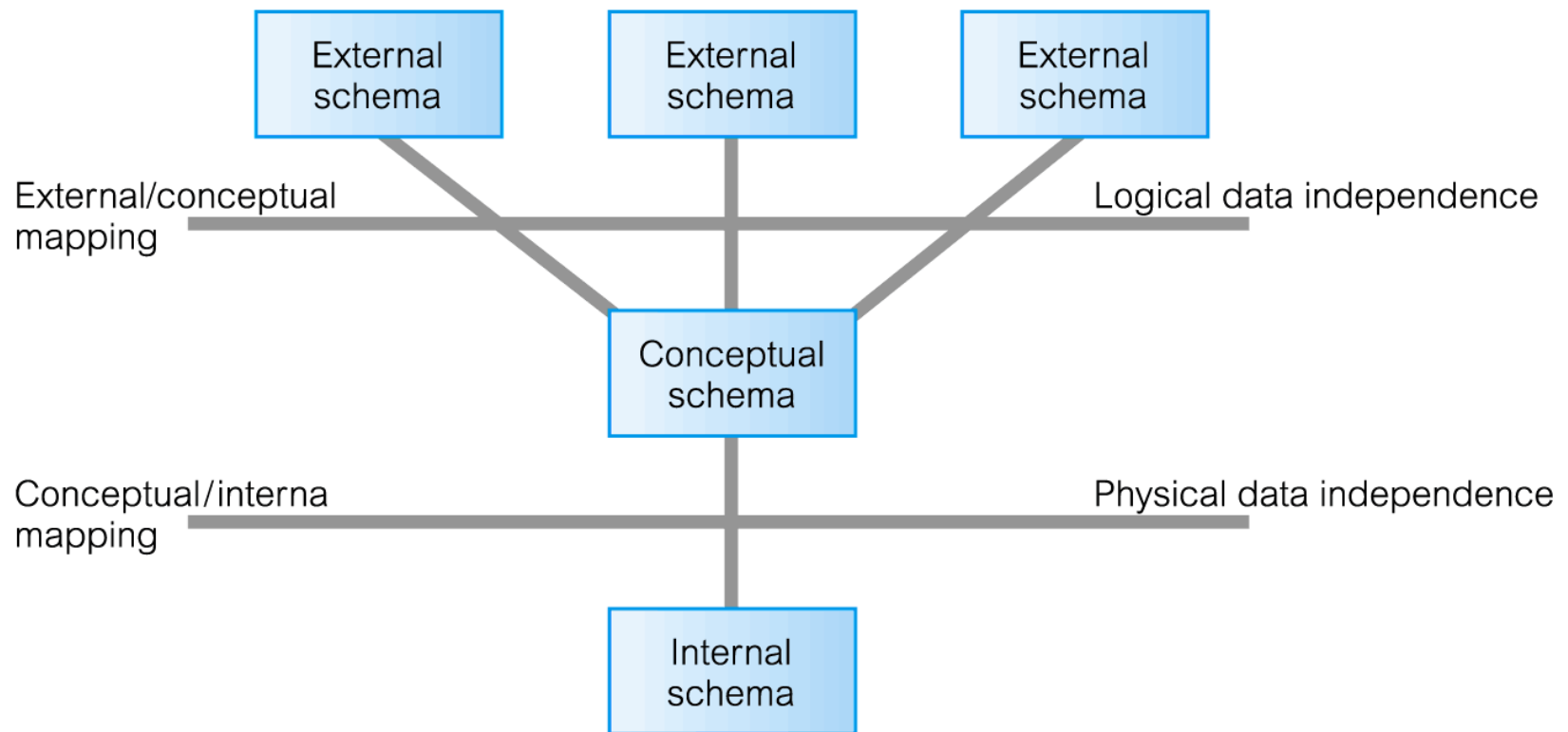
Data Independence

- **Logical Data Independence**
    - **Refers to immunity 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.**

Data Independence

- **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/devices).**
    - **Should not require change to conceptual or external schemas.**

Categories of Data Models

```
┌─────────────────────────┐
│       Conceptual        │
│       Data Models       │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│     Implementation      │
│       Data Models       │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│        Physical         │
│       Data Models       │
└─────────────────────────┘
```
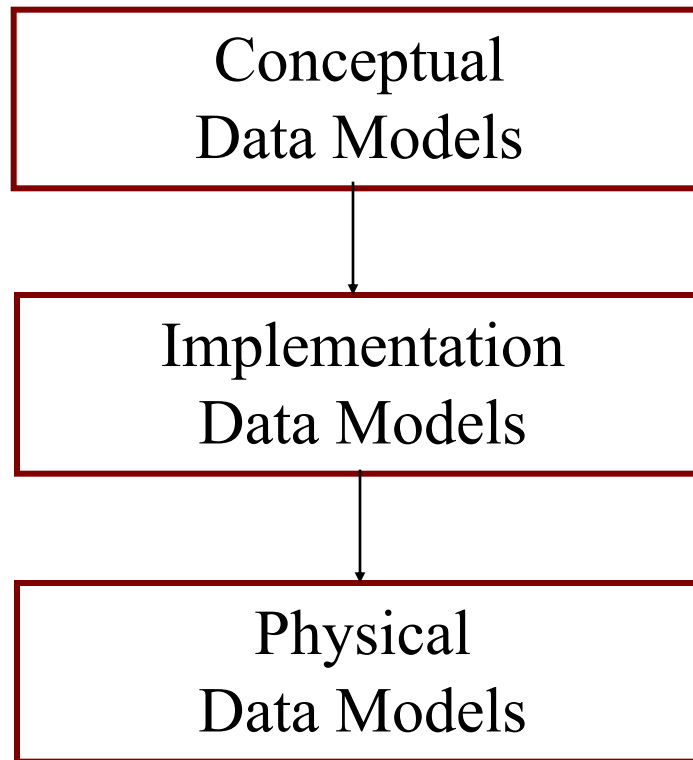
Data Model

- Data abstraction: hiding details of data storage that are not needed by most DB users
- Data model
  - Provides the necessary means to achieve data abstraction
  - A collection of concepts that can be used to describe the structure of a DB
    - Structure: data types, relationships & constraints on data
    - a set of basic operators on data
  - Concepts to specify dynamic aspect or behavior of a DB application
    - Allows DB designer to specify a set of valid user defined operators.

Categories of Data Models

- Categorized according to types of concepts
  - High level data model
    - Conceptual data model
    - Provide concepts that are close to the way users perceive data
  - Low level data model
    - Physical data model
    - Provides concept that describe the details of how data is stored in the computer
    - Meant for computer specialists, not for typical end users
  - Representational data model
    - Implementation data models
    - Provide concepts that maybe understood by end users but that are not far removed from the way data is organized with the computer
    - Hide some details of data storage but can be implemented on a computer system in direct way
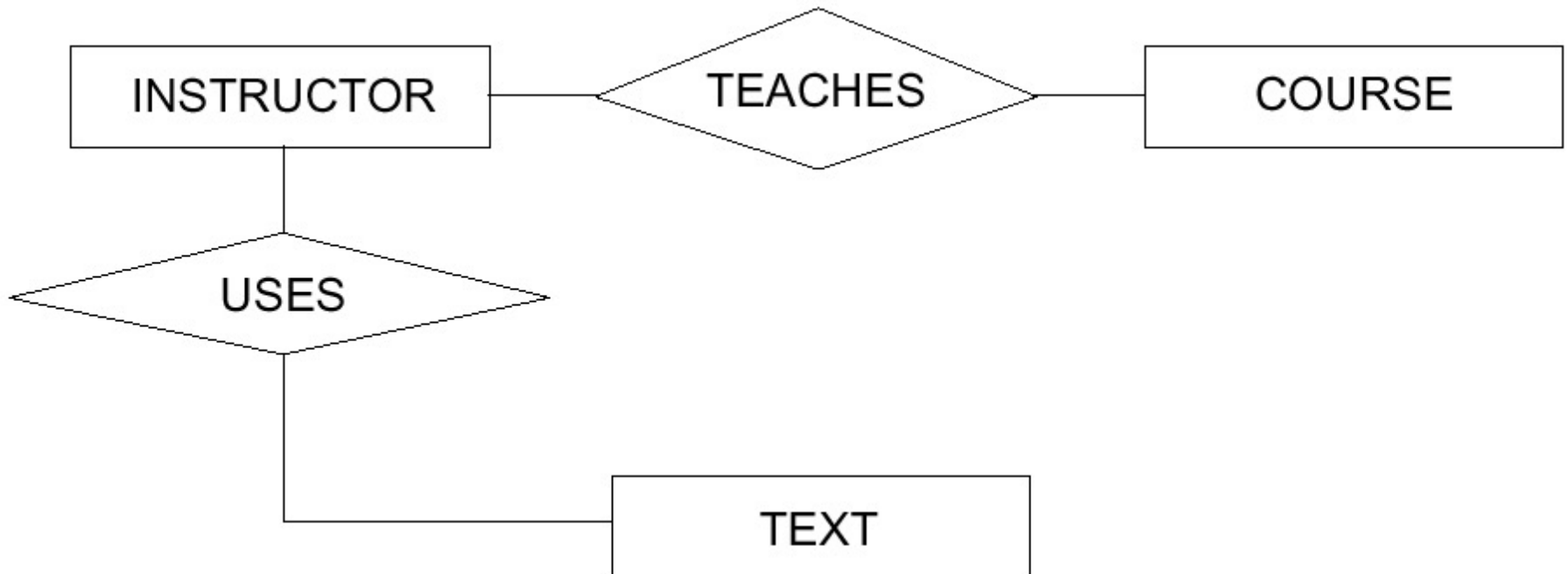
Conceptual Data Models

Conceptual data model uses

- Entity
  - a real world object or concept
- Attribute
  - property of interest that further describes an entity
- Relationship
  - represents an interaction among the entities

Example of conceptual data model

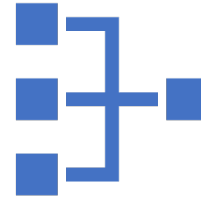- Entity-Relationship model (ER model)

An Example Conceptual Data Model

Implementation Data Model

Implementation data model

represents data by using record structures

record-based data models

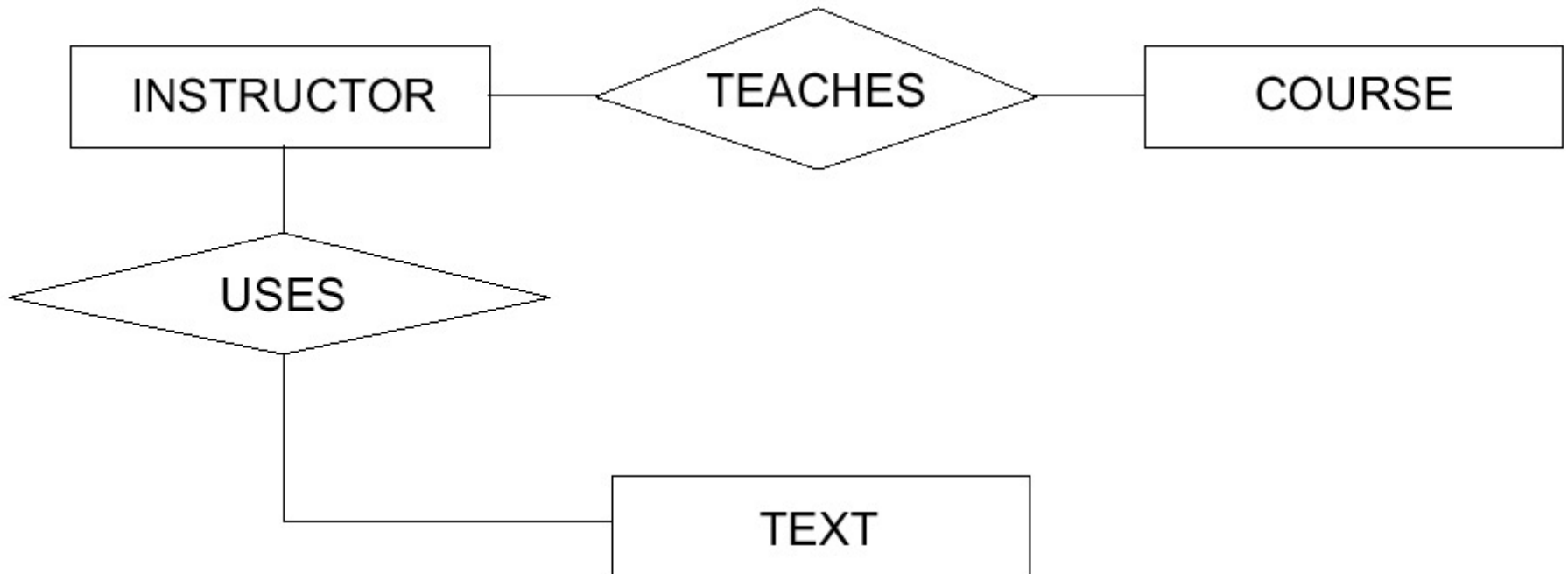**Examples of implementation data model**

relational data model

network data model

hierarchical data model

object data model (closer to conceptual data model)

An Example Conceptual Data Model

An Example of Data Model

員工編號	姓名	講授科目
060302	曹孝櫟	C001
060301	吳毅成	C004
060306	李毅郎	C002
060309	黃俊龍	C003
060308	彭文志	C005

課程編號	課程名稱	時間
C001	作業系統	星期四
C002	計算機組織	星期三
C003	編譯器	星期一
C004	演算法	星期二
C005	資料庫系統	星期五

員工編號	使用課本
060301	Operating Systems
060302	Algorithms
060306	Computer Architecture
060309	Compiler Design
060308	Database Systems

Relational Data Model

Branch

branchNo	street	city	postCode
B005	22 Deer Rd	London	SW1 4EH
B007	16 Argyll St	Aberdeen	AB2 3SU
B003	163 Main St	Glasgow	G11 9QX
B004	32 Manse Rd	Bristol	BS99 1NZ
B002	56 Clover Dr	London	NW10 6EU

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005
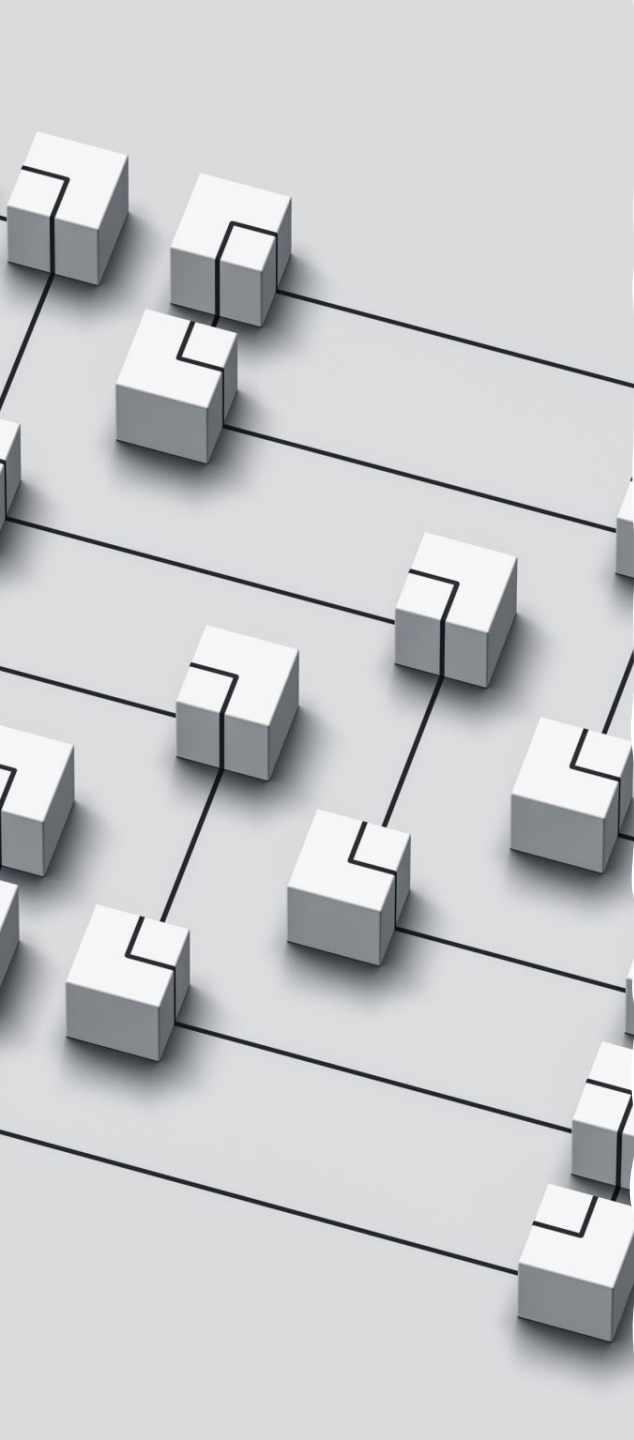
Physical Data Model

- Physical data model
  - describe how data is stored in the computer
  - record formats, record ordering, access paths

Schema

- Database schema
    - description of a database
    - specified during database design
    - is not expected to change frequently
    - Schema evolution: schema change
    - Intension of the schema
- Schema diagram: a displayed schema
- Schema construct: object in the schema
- Metadata (data about data) = schema + constraints
- DBMS stores metadata in the DBMS catalog (data dictionary)

An Example of Schema

STUDENT

Name	StudentNumber	Class	Major

COURSE

CourseName	CourseNumber	CreditHours	Department

PREREQUISITE

CourseNumber	PrerequisiteNumber

SECTION

SectionIdentifier	CourseNumber	Semester	Year	Instructor

GRADE_REPORT

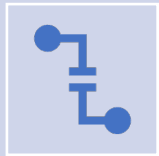| StudentNumber	SectionIdentifier	Grade

Database State

Database state (snapshot)

- Data in the DB at a particular moment in time
- Current set of occurrences or instances in the DB
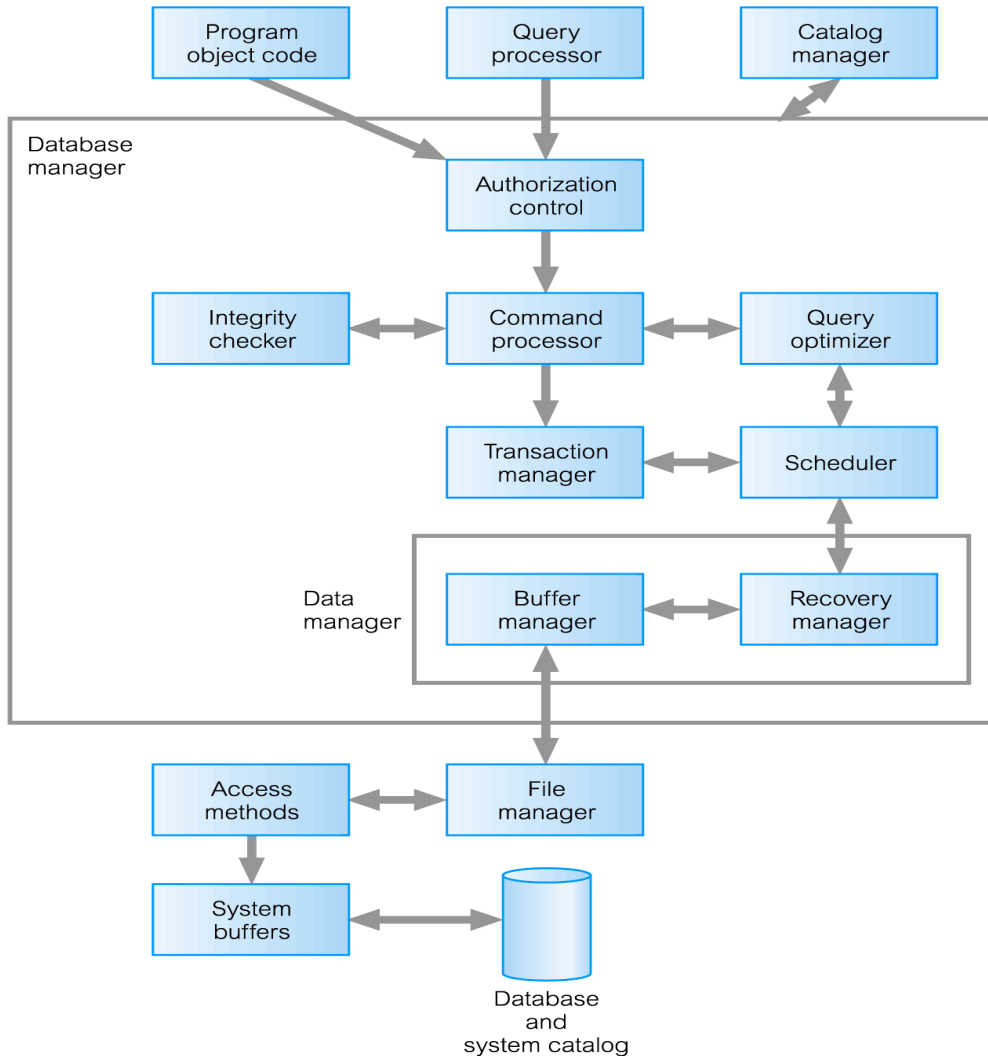- Extension of schema

DBMS

- is responsible for ensuring valid state
- Valid state: a states that satisfies the structure & constraints specified in the schema

Components of Database Manager

DBMS Languages

DBMS Languages

- DDL (data definition language): conceptual schema
- SDL (storage definition language): internal schema
- VDL (view definition language): view schema
- DML (data manipulation language)

SQL = DDL+ VDL + DML + constraints + schema evolution

Types of DML

- Types of DML
  - High level DML
    - nonprocedural, declarative
    - specifies which data to be retrieved
    - interactive or embedded in high level programming language
      - e.g. C + SQL, Visual BASIC +SQL
    - set-at-a-time
  - Low level DML
    - Procedural
    - specifies how data to be retrieved
    - record-at-time

Host Language

- Host language
  - high level programming language to embed DML
- Data sublanguage (embedded language)
  - DML embedded in host language
- Query language
  - High level DML used in a interactive maner

DBMS Interfaces

Graphical user interfaces

- Displays a schema to users in diagrammatic form
- Users specify query by manipulating diagram

Natural language interfaces

Interfaces for DBA

Database System Utilities

- Database utilities
  - help DBA in managing the DB system
  - Types of functions
    - Loading
      - Loading text files into DB
      - Conversion tools
    - Backup
      - Incremental backup
    - File organization
    - Performance monitoring

Self-Study

- Something about Convid 2019
  - 鍵盤救國https://www.businessweekly.com.tw/focus/blog/3001698
  - 口罩地圖 https://mask.pdis.nat.gov.tw
  - 類流感分析 https://fluforecast.cdc.gov.tw
  - **Novel Corona Virus 2019 Dataset**
  - Program languages
    - ASP, php, python ?
  - Web interface
  - Databases
    - MySQL, MS SQL, cloud DB, Big Query ?