

Introduction to Database Systems

Database Systems

Department of Computer Science, CNU
Prof. Nasridinov Aziz (aziz@chungbuk.ac.kr)

Table of Contents

1. What is Database?
2. Data Model
3. Database Management System (DBMS)
4. Database Systems
5. Database Languages
6. Recent Techs in Database Systems
7. Summary and Discussions

1. What is Database?

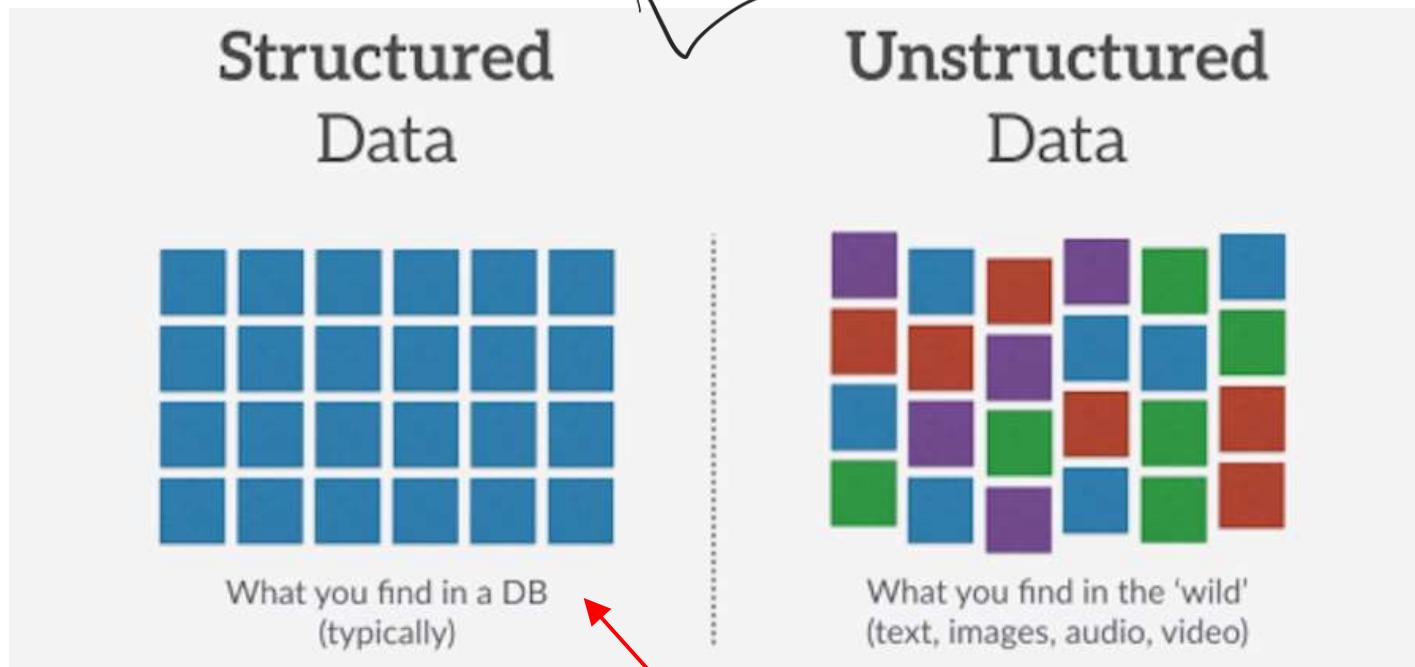
- ❖ What is data?
 - Since birth, we are surrounded with data
 - Since people first started writing, they have recorded their observations
 - Since computers were invented in the 1950s, data is known as **information that is stored or shared electronically**
 - In simple words, data means facts, numbers, charts, or information that a computer stores or uses

1. What is Database?

- ❖ What types of data exist?

- Structured vs. Unstructured data

Semi-structured data → JSON



In this lecture, we will focus on Structured Data

1. What is Database?

- ❖ Database
 - An organized collection of data
- ❖ Examples of Database Applications
 - Universities: student management, registration, grades
 - Airlines: reservations, schedules
 - Hospitals: patient data
 - Retail: customers, products, purchases, order track
 - Banking and finance
 - customer information, accounts, loans, and card usage

2. Data Model

❖ What is Data Model?

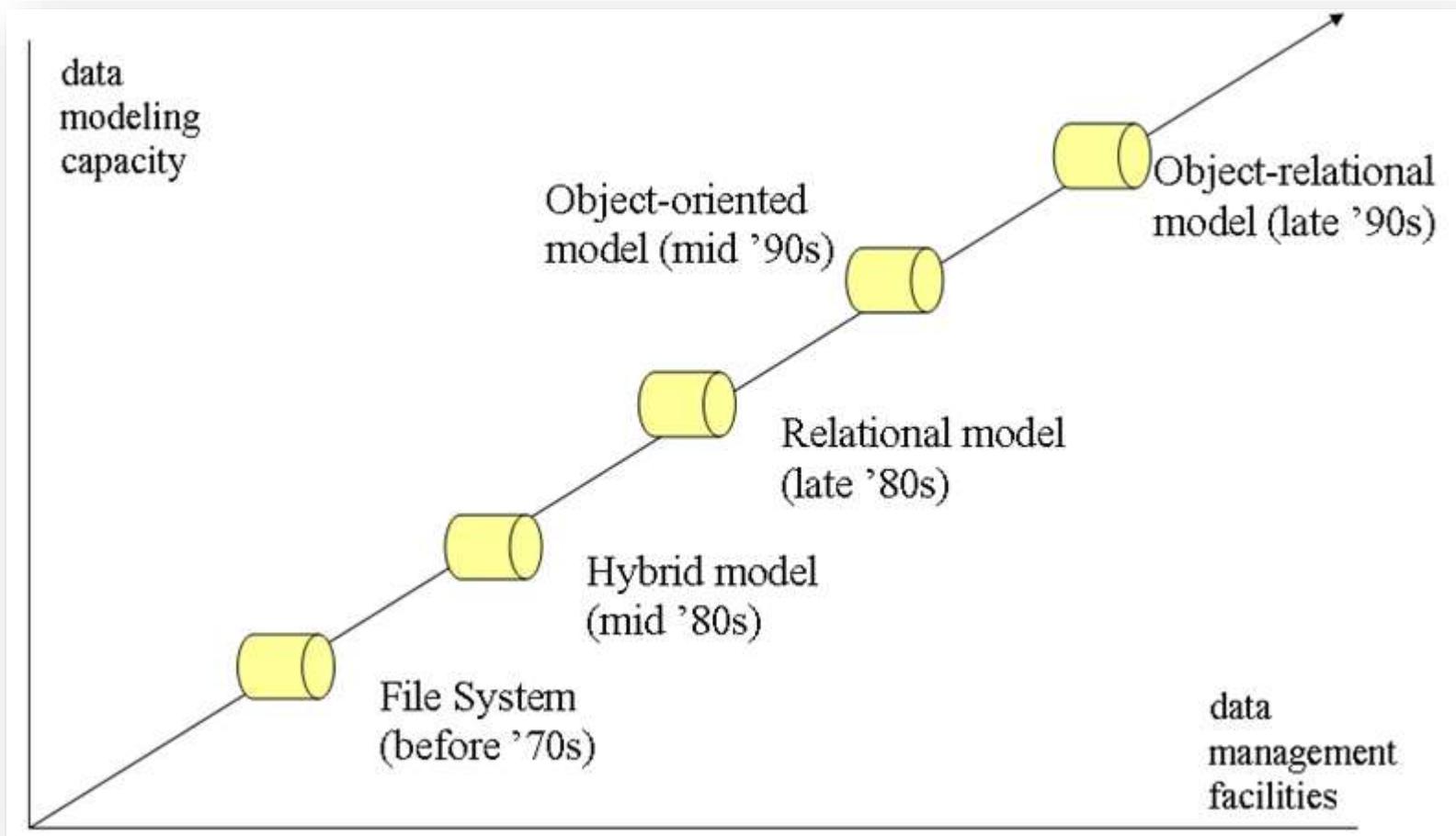
- Used to show how data is **stored**, **connected**, **accessed** and **updated** in the database

❖ Types of data models

- Hierarchical Model 계층형 모델
- Network Model 연결형 모델
- Hybrid Model (Combination of Hierarchical and Network Model)
- **Relational Model <- This lecture will focus on Relation Model**
- Object-Oriented Model
- Object-Relational Model

2. Data Model

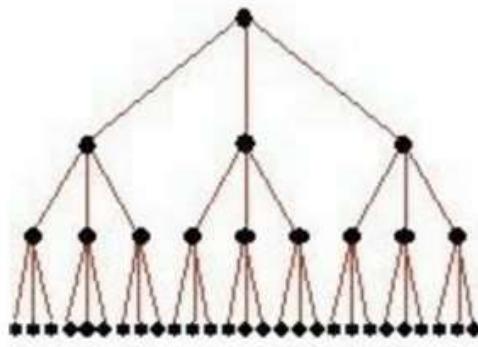
❖ History of Data Models



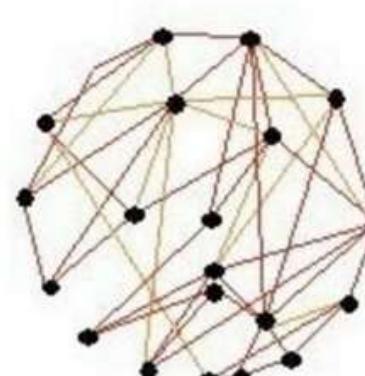
2. Data Model

❖ Hybrid Models

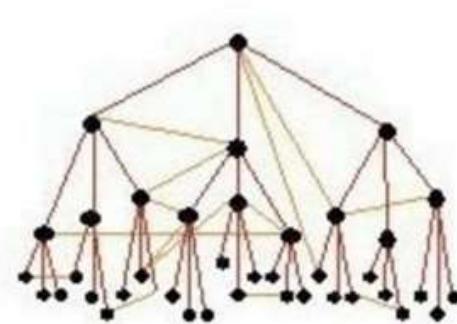
- **Hierarchical Data Model:** Organizes the data in the tree-like structure
- **Network Data Model:** Organizes the data in directed graph structure
- **Hybrid Data Model:** Combination of Hierarchical and Network Data Models



Hierarchy



Network



Hybrid

2. Data Model

❖ Relational Model

- Represents the database as a **collection of relations**
 - Relation = table

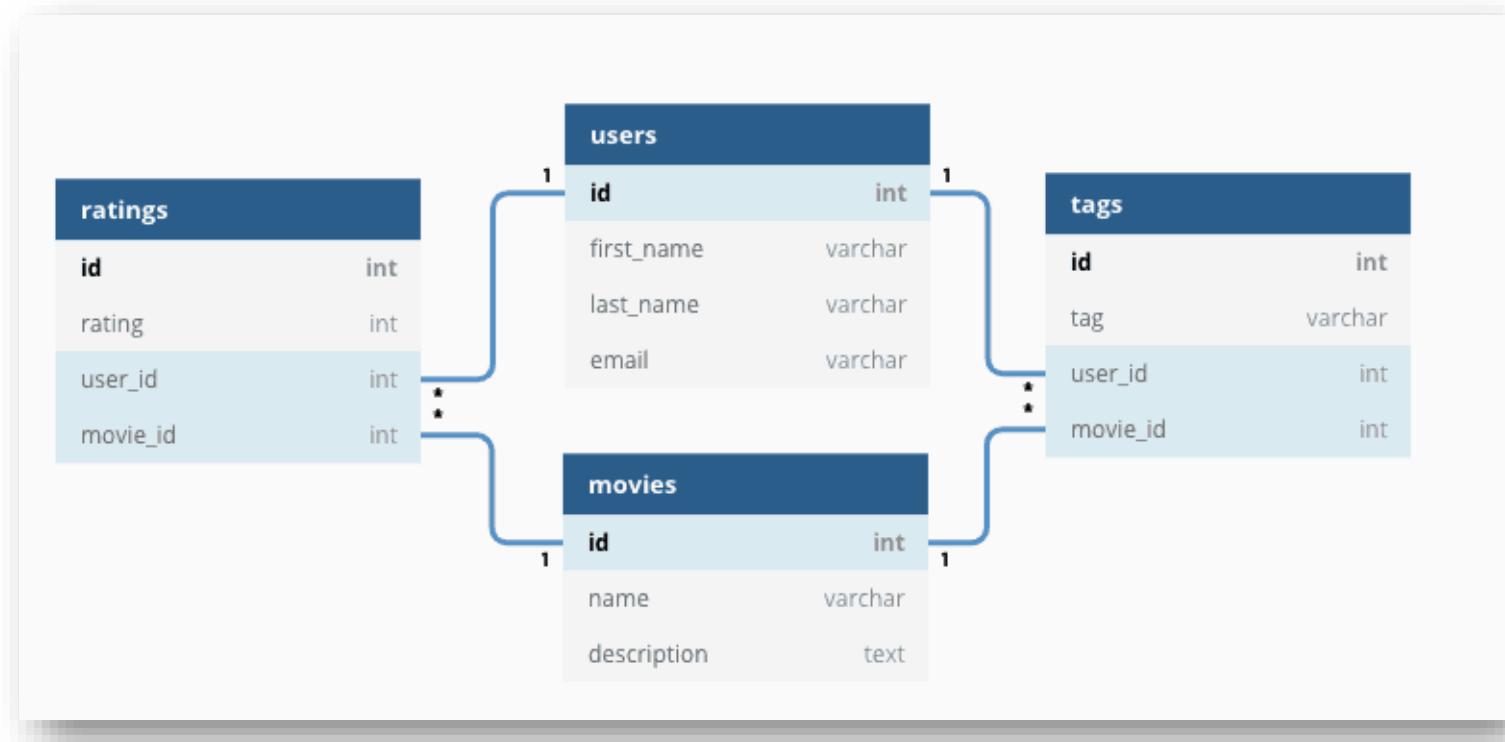
<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
10101	Srinivasan	Comp. Sci.	65000
58583	Califieri	History	62000
83821	Brandt	Comp. Sci.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

The *instructor* relation

2. Data Model

- ❖ What is relational database?

- Allows related data to be **stored across multiple tables**, and linked by establishing a **relationship between the tables**



3. Database Management System (DBMS)

❖ DBMS

- A software designed to **store, retrieve, define, and manage** data in a database

❖ Ranking of various well-known DBMS

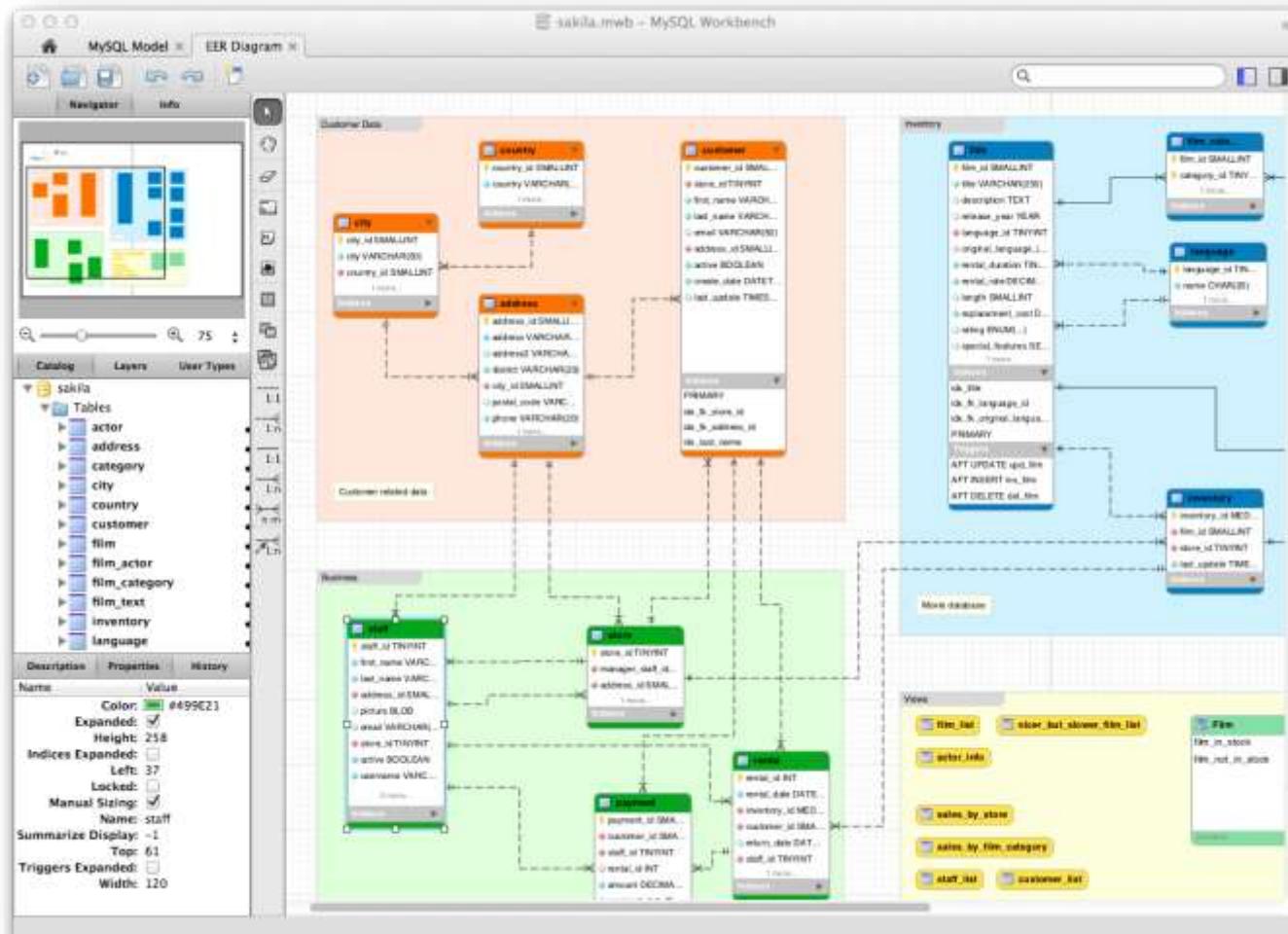
424 systems in ranking, September 2025

Rank				Database Model	Score		
	Sep 2025	Aug 2025	Sep 2024		Sep 2025	Aug 2025	Sep 2024
1.	1.	1.	1.	Oracle	Relational, Multi-model 	1170.62	-50.08 -115.97
2.	2.	2.	2.	MySQL	Relational, Multi-model 	891.77	-23.69 -137.72
3.	3.	3.	3.	Microsoft SQL Server	Relational, Multi-model 	717.32	-36.84 -90.45
4.	4.	4.	4.	PostgreSQL	Relational, Multi-model 	657.17	-14.08 +12.81
5.	5.	5.	5.	MongoDB 	Document, Multi-model 	380.50	-15.08 -29.74
6.	6.	↑ 7.	Snowflake	Relational		190.19	+11.29 +56.47
7.	7.	↓ 6.	Redis	Key-value, Multi-model 	145.17	-2.02 -4.25	
8.	8.	↑ 9.	IBM Db2	Relational, Multi-model 	124.19	-3.12 +1.14	
9.	9.	↑ 14.	Databricks	Multi-model 	124.06	+8.25 +39.82	
10.	10.	↓ 8.	Elasticsearch	Multi-model 	118.26	+3.99 -10.53	

3. Database Management System (DBMS)

RDBMS

- ❖ GUI Interface of MySQL



3. Database Management System (DBMS)

❖ Query

- A query in a database is a request for information from a DBMS
 - Retrieve data or change (add or remove) information in a database

The screenshot shows the MySQL Workbench interface. On the left, the Navigator pane displays the schema structure, including the 'world' schema which contains tables like 'city', 'country', and 'language'. The central area is a 'Query Editor' window titled 'Query 1' with the query `1 • SELECT * FROM world.country;`. Below the query, the text '1. Query' is highlighted in red. To the right of the query is a 'Result Grid' displaying data from the 'country' table. The first few rows of the result grid are:

Code	Name	Continent	Region	SurfaceArea	IndepYear	Population	LifeExpect
ABW	Aruba	North America	Caribbean	193.00	1919	103000	78.4
AFG	Afghanistan	Asia	Southern and Central Asia	652090.00	1919	22720000	45.9
AGO	Angola	Africa	Central Africa	1246700.00	1973	12878000	38.3
AIA	Anguilla	North America	Caribbean	96.00		8000	76.1

An arrow points from the text '1. Query' in the query editor to the result grid. At the bottom of the screen, the text '2. Result of query' is displayed in red.

3. Database Management System (DBMS)

❖ Purpose of DBMS

- Allows to create a new database
- Allows you to specify the structure of the database
- Allows users to query and modify data efficiently
- Protects data from system failure or unauthorized users
- Controls access to the database by multiple users at the same time

4. Database Systems

❖ Database Schema

- The overall logical structure of the database, also called **metadata**
 - Ex: department(dept_name, building, budget) → schema.

instance

The diagram illustrates the relationship between database schema and instances. On the left, a table structure is shown with columns labeled *dept_name*, *building*, and *budget*. This represents the schema or metadata. On the right, a specific instance of this schema is shown as a table with data rows: Comp. Sci., Biology, Elec. Eng., Music, Finance, History, and Physics. The entire table is enclosed in a light gray box. A handwritten note next to the table says "→ Structure, metadata, schema". A curved bracket on the left side of the table spans the column headers and the first few data rows, grouping them under the label "instance".

<i>dept_name</i>	<i>building</i>	<i>budget</i>
Comp. Sci.	Taylor	100000
Biology	Watson	90000
Elec. Eng.	Taylor	85000
Music	Packard	80000
Finance	Painter	120000
History	Painter	50000
Physics	Watson	70000

→ Structure, metadata, schema

The *department* table

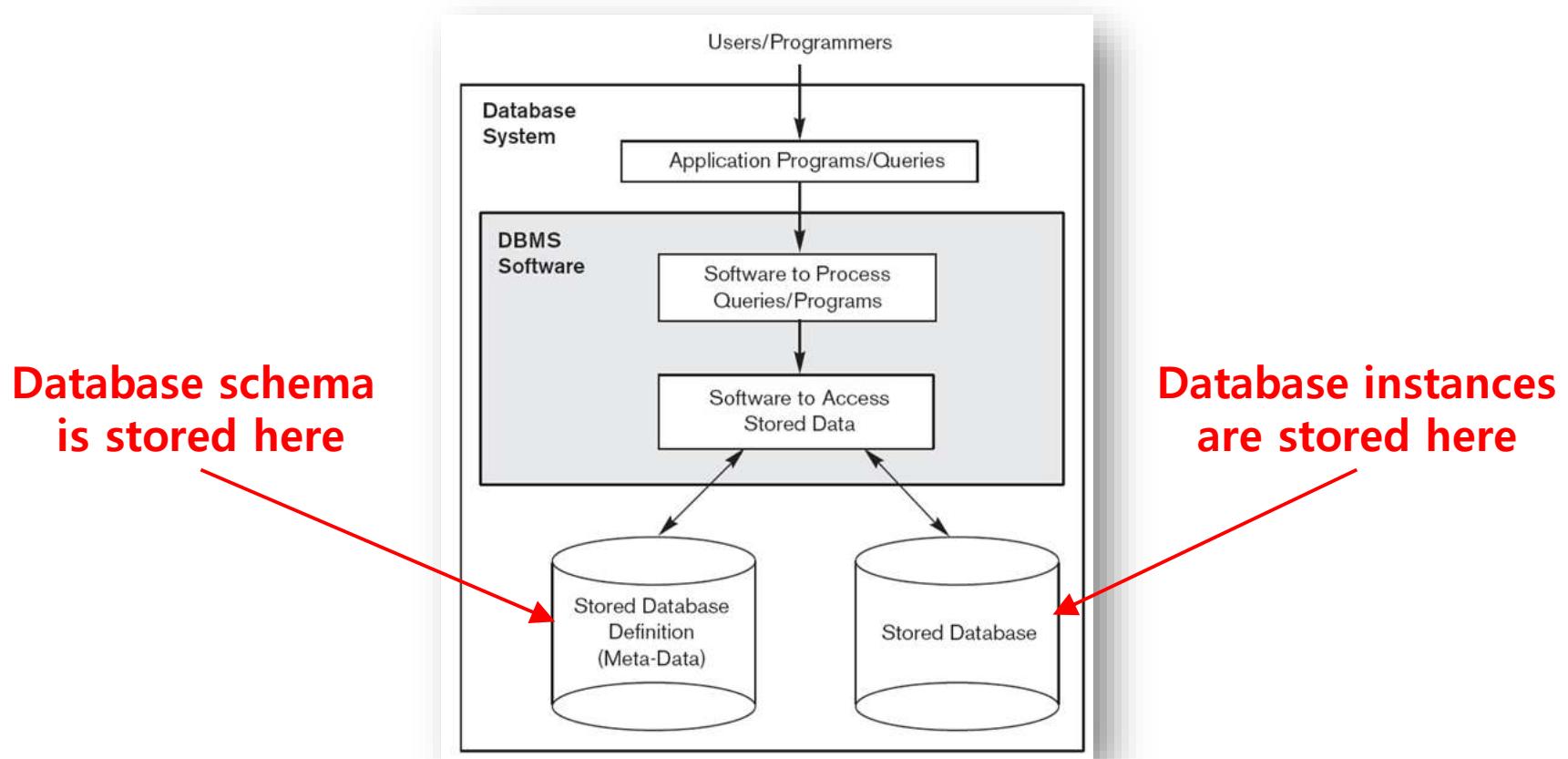
❖ Database Instance

- The actual content of the database at a particular point in time

4. Database Systems

❖ What is Database Systems?

- Users, application programs, DBMS and stored database are referred to as a database system



4. Database Systems

❖ Characteristics of Database Systems

- Allows multiple users to access and manipulate data in the database simultaneously
*e.g.) 종합병원 등.
도서관*
- Eliminates data redundancy by storing data in a centralized database
- Enforces integrity constraints to ensure data consistency and accuracy
- Enables data independence by separation of data and application programs
- Provides security features to protect the data from unauthorized access
- Supports backup and recovery features to prevent data loss

4. Database Systems

- ❖ Database users
 - Naïve Users
 - Users with no knowledge in DBMS, but frequently use the database application in their daily life
 - Database Designers
 - Users who design the structure of database
 - tables, indexes, views, triggers, stored procedures and constraints
 - Application Programmers
 - Back-end developers who design, debug, test, and maintain set of programs to interact with database

4. Database Systems

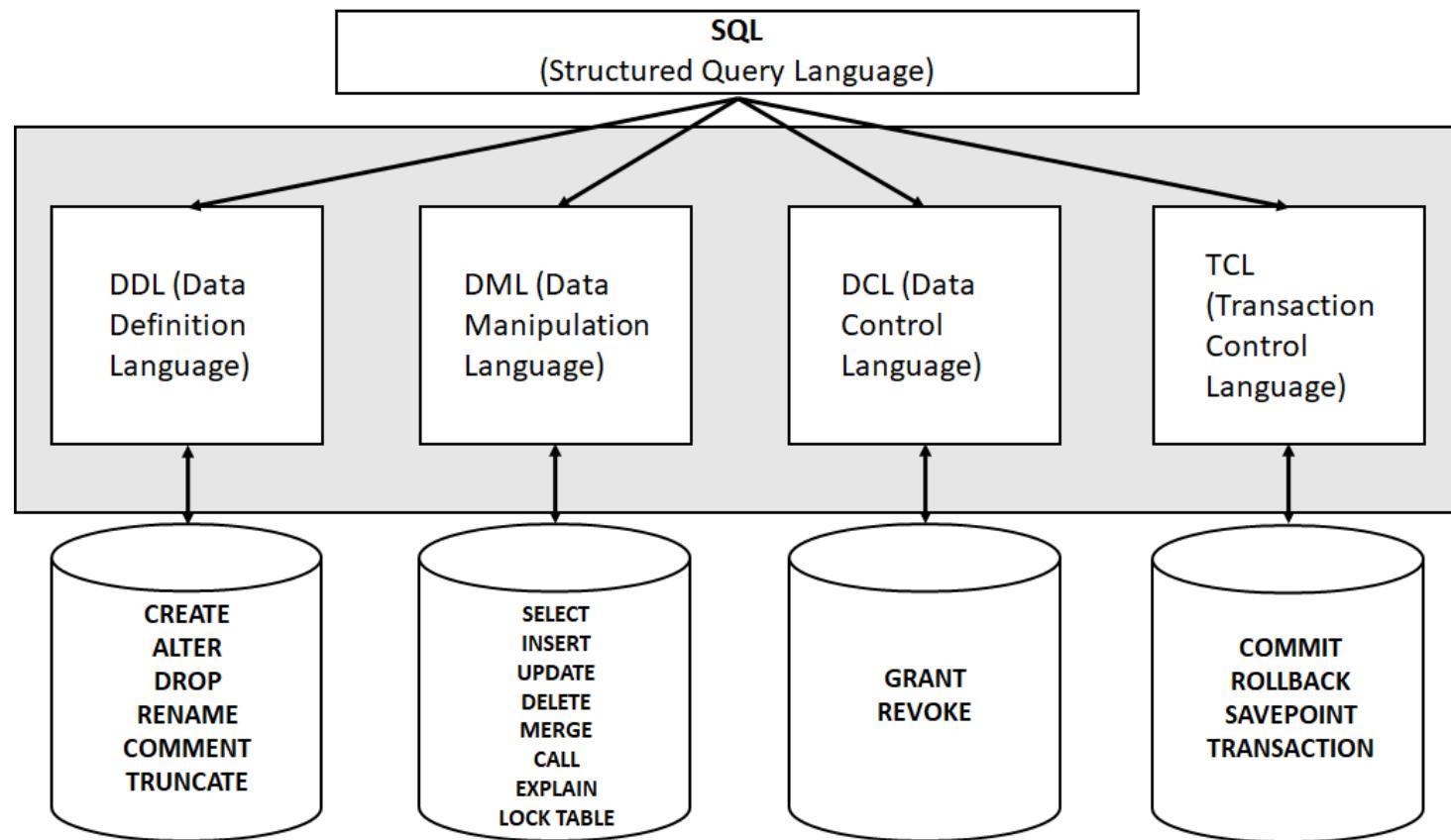
- ❖ Database users
 - Sophisticated users
 - Interact with database without writing programs. Typically, using database query language like SQL
 - Database Administrators (DBA)
 - Routine maintenance
 - Granting of authorization for data access
 - Backup and recovery
 - Database tuning and performance monitoring

5. Database Languages

- ❖ Structural Query Language (SQL)
 - Define queries to access and manipulate the data from database
 - A procedural language, not a programming ~~language~~
язык *язык*
 - A standard language for RDBMS → software *.
 - Oracle, MySQL, Microsoft SQL and others
 - SQL statements are divided into four major categories
 - Data Definition Language (DDL)
 - Data Manipulation Language (DML)
 - Data Control Language (DCL)
 - Transaction Control Language (TCL)

5. Database Languages

- ❖ Structural Query Language (SQL)



5. Database Languages

❖ Data Definition Language (DDL)

- A language for defining the database schema
 - Used to **create** and **modify** the structure of your tables and database objects
- Example (Creating a new table)

```
CREATE TABLE department(  
    dept_name      varchar(20),  
    building       varchar(20),  
    budget         numeric(8,2))
```

schema
metadata

DDL → ~~SQL~~ ~~SQL~~ ~~SQL~~

- Other DDL statements include **ALTER**, **DROP**, **RENAME**, **COMMENT** and **TRUNCATE**

설명

설명

5. Database Languages

zyt

❖ Data Manipulation Language (DML)

- A language for **searching**, **modifying**, **inserting** and **deleting** the desired data in the database
 - DML also known as query language
- Example (Selecting rows)

SELECT *name*

FROM *instructor*

WHERE *dept_name*=‘Comp.Sci.’

- Other DML statements include **INSERT**, **UPDATE**, **DELETE** and others

5. Database Languages

Security + Protection

❖ Data Control Language (DCL)

- Mainly deal with the **rights, permissions, and other controls** of the database system

- Example (Granting privilege)

GRANT SELECT ON department

TO 'aziz'@'localhost';

GRANT = 허가권여

REVOKE = 허가권제거

- Other DCL statements include REVOKE

5. Database Languages

❖ Transaction Control Language (TCL)

- Used to manage **data security**, **data integrity**, **data recovery** and **data concurrency**

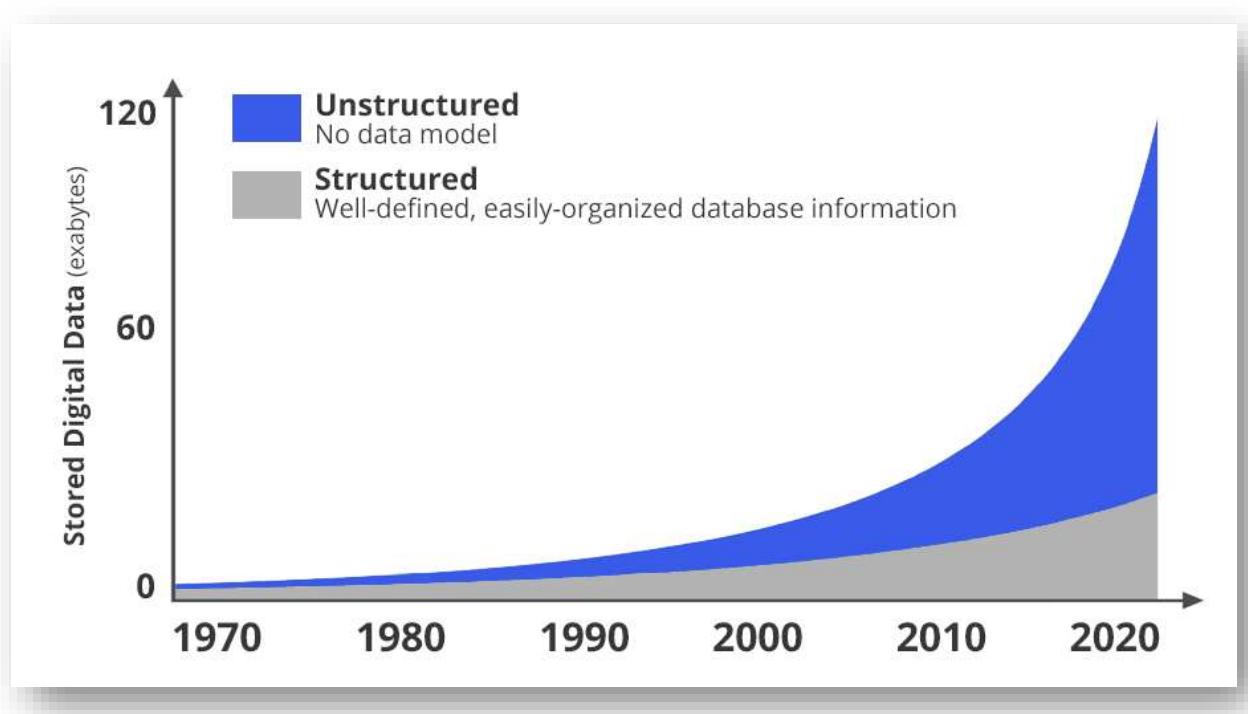
동작성

Correctness
Transaction = 일련의 어떤 변화..?

- TCL Commands
 - COMMIT
 - ROLLBACK
 - SAVEPOINT
 - SET TRANSACTION

6. Recent Techs in Database Systems

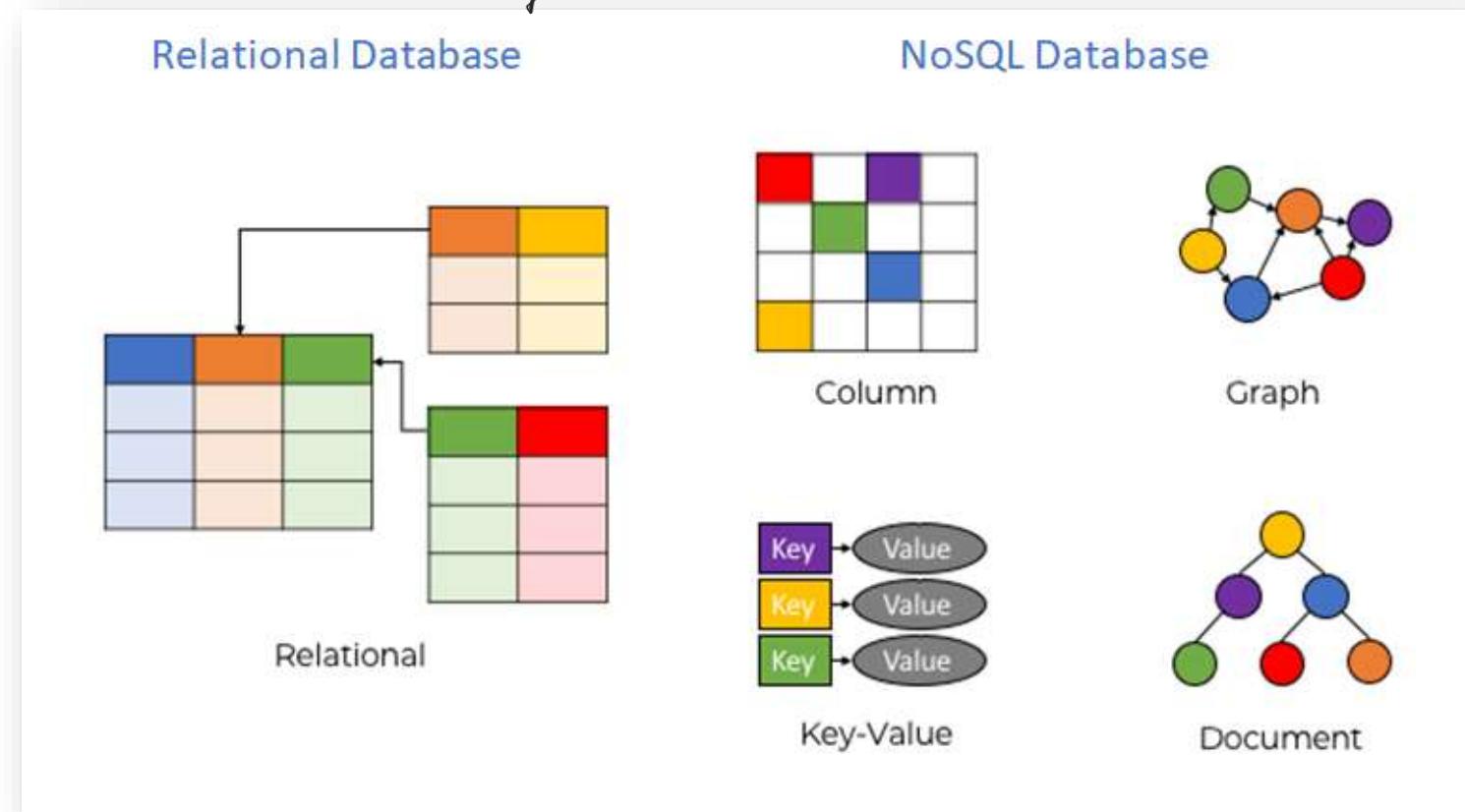
- ❖ According to Seagate, the volume of data generated worldwide will increase from 33 in 2018 to about 175 zettabytes in 2025
- ❖ Data Growth



6. Recent Techs in Database Systems

❖ NoSQL

- Non-relational databases



6. Recent Techs in Database Systems

❖ NoSQL

- Example of data in MongoDB (Document database)

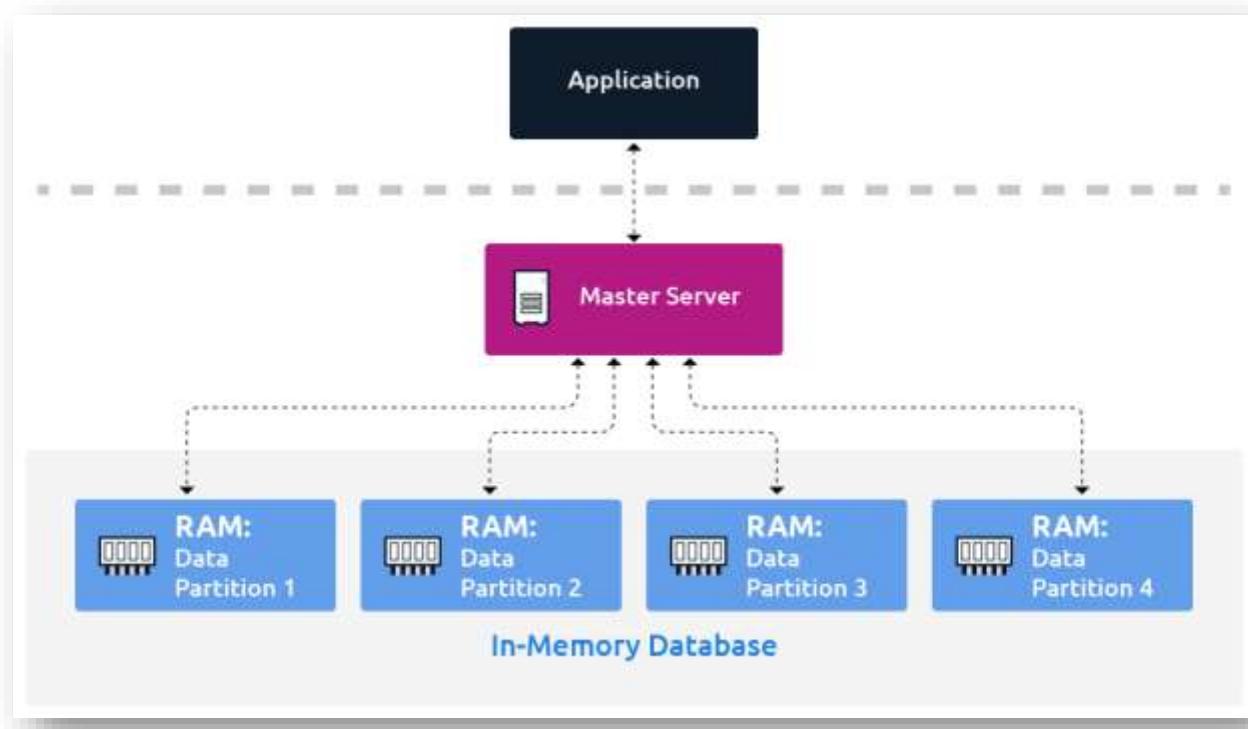
```
{  
    "_id" : 1,  
    "artistName" : { "Iron Maiden" },  
    "albums" : [  
        {  
            "albumname" : 'The Book of Souls',  
            "datereleased" : 2015,  
            "genre" : 'Hard Rock'  
        }, {  
            "albumname" : 'Killers',  
            "datereleased" : 1981,  
            "genre" : 'Hard Rock'  
        }, {  
            "albumname" : 'Power Slave',  
            "datereleased" : 1984,  
            "genre" : 'Hard Rock'  
        }, {  
            "albumname" : 'Somewhere in Time',  
            "datereleased" : 1986,  
            "genre" : 'Hard Rock'  
        }  
    ]  
}
```

<Data stored in JSON format>

6. Recent Techs in Database Systems

❖ In-Memory Databases

- Data is stored directly in the computer's main memory (RAM)
 - Enable minimal response times by eliminating the need to access hard disks



6. Recent Techs in Database Systems

- ❖ In-Memory Databases

- Popular DBMS



7. Summary and Discussions

❖ Database

- An organized collection of data

❖ Database Management Systems (DBMS)

- A software designed to store, retrieve, define, and manage data in a database
- MySQL

❖ Meta-Data (System Catalog or Data Dictionary) Schema

- Describes the structure of the database

❖ Database Systems

- Users, application programs, DBMS and stored database are referred to as a database system

7. Summary and Discussions

- ❖ Data Models are used to show how data is stored, connected, accessed and updated in the DBMS
- ❖ Types of data models
 - Hierarchical Model
 - Network Model
 - Relational Model
 - Object-Oriented Model
 - Object-Relational Model
- ❖ Relational Model
 - Represents the database as a collection of relations

7. Summary and Discussions

- ❖ Structural Query Language (SQL)
 - Define queries to access and manipulate the data from database
- ❖ SQL statements are divided into four major categories
 - Data Definition Language (DDL)
 - Data Manipulation Language (DML)
 - Data Control Language (DCL)
 - Transaction Control Language (TCL)
- ❖ Recent Techs in DB
 - NoSQL Databases
 - In-Memory Databases

Quiz

1. What is Big Data? Where do you often encounter the Big Data?
2. What do you think where it is NOT recommended to use the database?
3. Given the following relation, indicate database schema and instances.

ID	Name	Major	Grade	Email
1000	Tim	Computer	Male	tim@gmail.com
1001	Sonya	Art	Female	sonya@naver.com
1002	Brain	Social	Male	brain@yahoo.com
1003	Natasha	Math	Female	natasha@outlook.com

The *student* relation